POWER

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PURPOSEFUL ANECDOTES

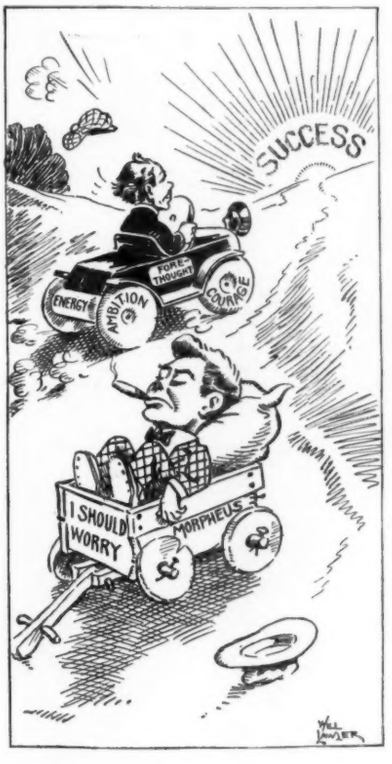
SOME years ago a young engineer was in charge of a small power station in the country. He lived as a unit with that plant and as it went so did he. There was not much spare money for improvements, but he did the best he could with what was available and was mindful of the company's interests.

The manager was not of this type; his interests were how he could bring in the most for himself without actually stealing. He thought as much of half a dozen different things as the welfare of the business.

There was a lack of sympathy between these two men when there should have been co-operation.

The engineer worked with the thought that some day there would be a better position waiting for him, yet he never failed to exercise the best efforts of which he was capable to run his plant as well as it could be run. So in time he went to that better position which his own personality and sincerity had earned for him.

The Object



It happened that a man came to the plant that he had left who was the exact counterpart of the manager as far as temperament went. He was paid more money than the first engineer, much money was spent to make the plant easier to operate and more help was employed.

With all of these advantages it would seem as if the service should be excellent and the machinery in fine condition, but such was not the case. Instead of looking ahead and forestalling trouble, the policy of the new engineer was to wait until the service was interrupted or some accident happened before he did any work. He did not consider it necessary to thoroughly clean the boilers once in a while as the man preceding him had done, and yet he said they were not large enough to supply the engine. He did not take the trouble to personally inspect repairs on intricate machinery so that he might feel that it was all right for its work, but took the word of subordinates who should not have been expected to know. He heard no complaint from the manager, so he thought he was doing just as he should and, as he reasoned, why should he work hard when there was no incentive to do so?

From the foregoing comparison of these two men, many will be tempted to remark that the first was a fool to work so hard when the second has all the easier things of life.

It is a foregone conclusion that there must be an end to such good times, and when the day of reckoning comes how will the second engineer fare? Is he preparing himself to step to a higher position or not? Will not the name of that badly conducted plant follow him for some time and, as he had no perceptible object in view there, how will he know what to do if he should be so fortunate as to get charge of a plant where the owners believe in efficient operation?

Any young engineer can view the examples of the two men with regard to himself and then consider whether the object that he has in view may be some day worth the while.

Contributed by G. H. KIMBALL, *East Dedham, Mass.*

Lowellville, Ohio, Turbine Plant

By Warren O. Rogers

SYNOPSIS—The present capacity of the plant is 15,000 kw. in electrical output. Water-tube boilers equipped with underfeed stokers generate steam at 195 lb. pressure, superheated 150 deg. The feed-water heaters are arranged on the multiple-unit system, which permits cutting either one out of service without interfering with the plant operation. Fuel is handled by a skip-hoist system and endless cable-drawn cars, which carry the coal from the crusher to the coal bunker in the boiler house.

Electric power is generated for the Mahoning & Shenango Railway & Light Co., Youngstown, Ohio, at three power houses—North Avenue, Ellwood City and Lowellville; the last named being the most modern and efficient and of the largest rated capacity. The North Avenue plant has a capacity of 12,000 kw., or just four times that of 10 years ago. The Ellwood City plant is operated partly by water power from the Connoquenessing Creek and partly by steam, the total capacity being about 2200 kw.

The Lowellville plant is about seven miles southeast of Youngstown on the Mahoning River, which furnishes all the water needed for condensing purposes and for makeup.

The plant contains but two generating units, Fig. 1, each of 7500-kw. capacity or, 9375 kv.-a., a total output at 80 per cent. power factor of 18,750 kv.-a., or 15,000 kw. Current is generated at 2300 volts, three-phase, 60-cycle at 1800 r.p.m. The steam pressure is 195 lb., which is higher than that carried in the average power plant, but it is not exceptional. Air for cooling the generators is taken from the outside of the building through a metal air duct, which is also open to the basement.

Along one side and about central of the room there are two 125-kw., two-stage, turbine-driven exciters running at 2400 r.p.m. At the generator end of each turbine is a 12x30x24-in. steam-driven air pump, Fig. 2. These pumps work with the two surface condensers. The valve gear in the steam end is of the Corliss positive type.

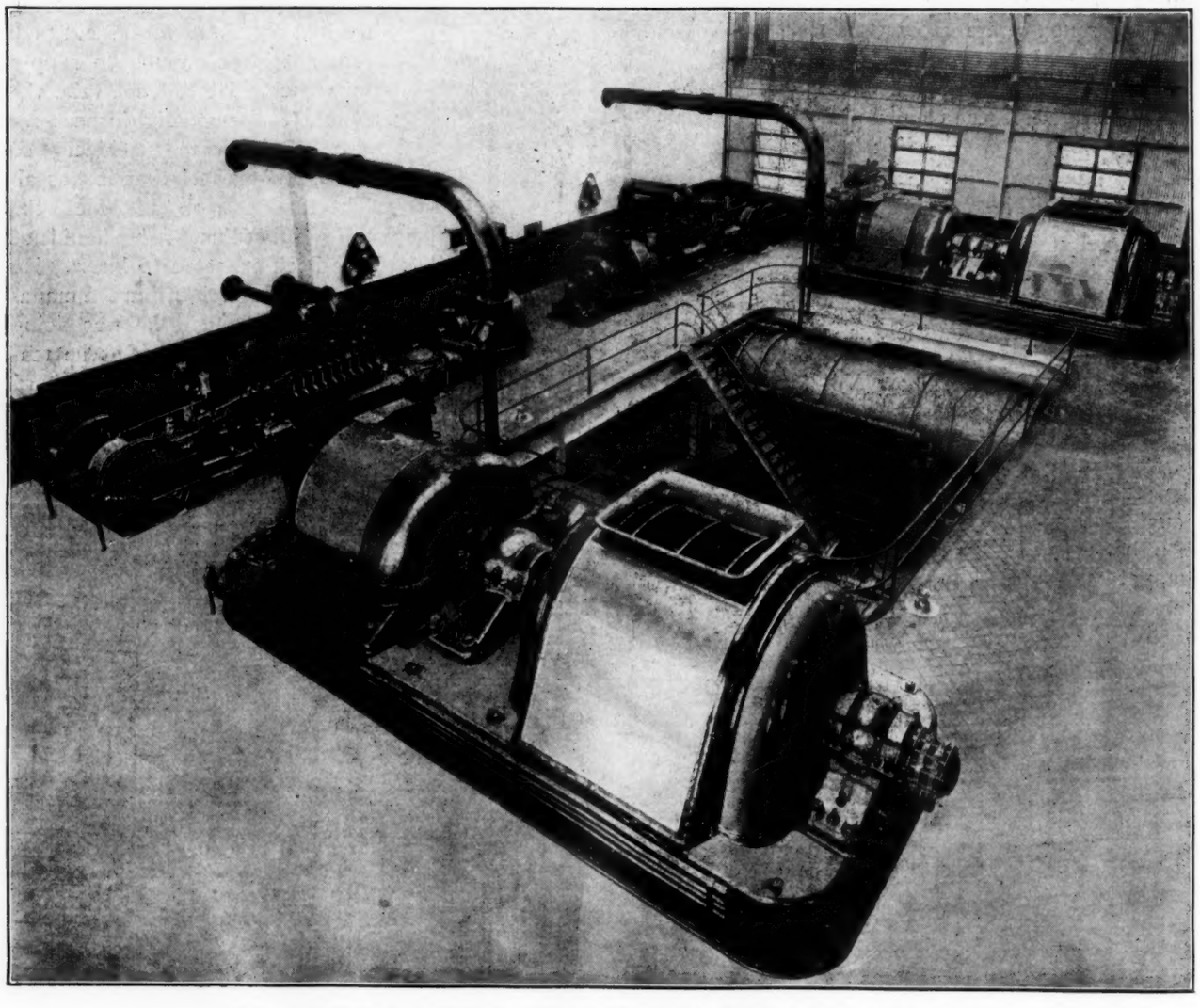


FIG. 1. GENERAL VIEW OF THE TURBINE ROOM FROM THE BALCONY

Both condensers are in the basement and are placed as shown in Fig. 3. The steam and water connections are at the side at opposite ends. Each condenser contains 22,500 sq.ft. of cooling surface made up of 1-in. tubes. This allows 3 sq.ft. per kilowatt of turbine output. Circulating water is supplied to each condenser by a 24-in. standard volute centrifugal pump, driven by a 12x15-in. horizontal, side-crank engine. Each pump has a capacity of 18,000 gal. of water per min. The engine and pump are connected by a flexible coupling.

All condensing apparatus, with the exception of the air pumps, is in the basement, which is open between the turbines, as shown in Figs. 1 and 2. An iron stairway communicates with the turbine-room floor. The open-floor arrangement is convenient for the watch engineer to observe the operation of the condensing apparatus, although a man is on duty in the basement during each shift.

The two 5000-hp. open feed-water heaters in the basement are operated on the multiple-unit system. When the plant was first built but one heater and purifier was installed. A second, of practically the same size and type, was put in later. These heaters were connected as shown in Fig. 9, and the two operate as a single unit. The float in the outside float box of the newest heater operates a cold-water regulating valve, which admits the water to a dividing box, whence it overflows through two V-notch weirs, so that the water-supply is divided between the two heaters.

Valves are provided in the two pipe lines leading from the dividing box, in the two branches of the pump supply pipe, and in the two branches of the vent pipe communicating with the steam space of the heaters and the top of the float box. There are also valves in the steam-inlet pipe, which make it possible to cut either heater out, while the other remains in service.

Owing to the fact that the two heaters were installed at different times and in order to utilize the piping already in place when the second was installed, a preference valve was placed in the free exhaust to the atmosphere, so that an adequate steam supply to both heaters would be had. This valve is of the multiported type, suitable for a maximum pressure of ¾ lb. per sq.in. Each valve disk is held to its seat by an independent spring, the tension of which is adjusted simultaneously by moving a pressure plate either up or down.

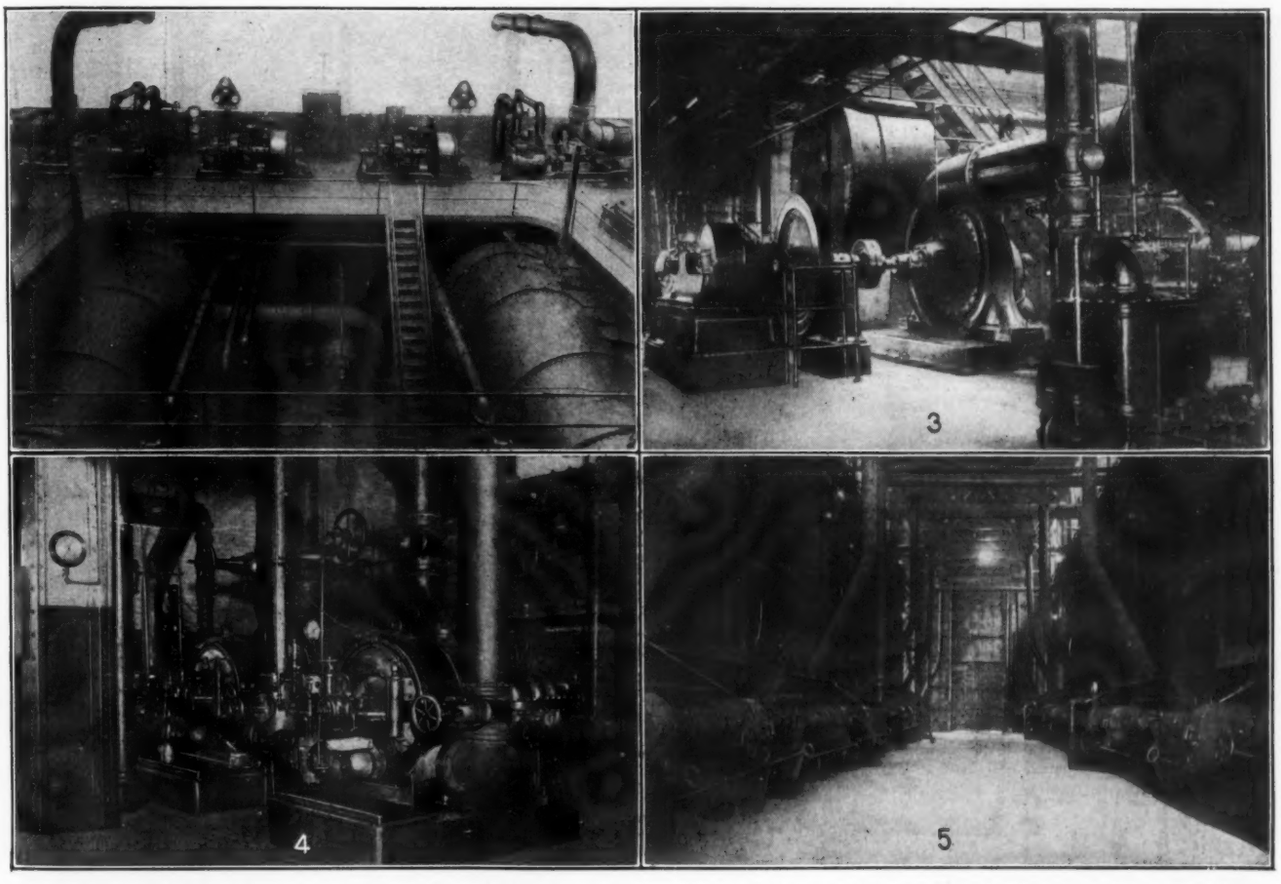


FIG. 2. CONDENSERS, AIR PUMPS AND ELECTRIC UNITS. FIG. 3. CONDENSERS AND ENGINE-DRIVEN CIRCULATING PUMPS. FIG. 4. BOILER-FEED PUMPS. FIG. 5. BOILER ROOM

Hotwell water is handled by either a turbine or a motor-driven, 4-in. volute pump. These units are alongside one of the heaters. Boiler-feed water is taken from the heaters by two 4-in., three-stage volute pumps, Fig. 4, each driven by a steam turbine at 2800 r.p.m. There is also a 12&18½x8½x10-in. compound pump used for either boiler feed or as a house pump, and held as an emergency unit. A smaller 7x10x10-in. duplex pump is used for the station water-supply, which is pumped to a tower-supported tank. This is shown in Fig. 7, which is a general view of the power house from the railroad track.

The nine water-tube boilers are arranged in two rows, Fig. 5, facing a central operating floor—five on one side and four on the other. Each contains 6000 sq.ft. of heating surface; figuring 10 sq.ft. per rated horsepower,

this gives 600 hp. per boiler, or a total of 5400 hp.—1 boiler-hp. for each 2.72 kw. in turbine output at normal rating. Each furnace is equipped with a seven-retort underfeed stoker. The latter are driven by four 5¼x6-in. vertical engines, the speed being regulated by the air pressure in the air ducts, which is governed by the steam pressure through a system of draft control. The boilers are equipped with superheaters that increase the steam temperature, at a pressure of 195 lb., 150 deg. The draft of each boiler is indicated by a differential draft gage, and the tubes are cleaned by a system of tube cleaners. Forced draft is supplied by two 12-ft. fans each driven by an 8x8-in. vertical engine, and one fan driven by a 12x15-in. engine and governed by a steam regulator and engine throttling governors. Two of the fans have a capacity of 54,000 cu.ft. of air per min. each, the other, 60,000 cu.ft. These engines and fans are in the basement under the care of the pumpman. An elevation of the plant is shown in Fig. 8.

Coal- and Ash-Handling Apparatus

The coal-handling outfit is shown in Fig. 6. It consists of a double 1-ton electrically operated skip hoist with a capacity of about 125 tons per hour as a hoisting unit. Coal is dumped from the cars into a concrete pit from which it is discharged into the empty skips and elevated to the top of the hoist. Here it is discharged into the hopper of a set of crushing rolls and made ready for loading into 2-ton cars running on a railway on a trestle about 80 ft. high. This railway distributes the coal to the bunker of the boiler room, the cars being run by a motor-driven endless cable. Ashes are dropped from the stokers into the ashpits. When ready to dispose of them, a sliding gate is opened and they are hoed into an ash car that runs over a track to the hoist elevator, and dumped into an ashpit, from which they are elevated by the skip hoist and discharged into a bin shown at the lower part of Fig. 6. From this bin the ashes are discharged through spouts into standard gage railroad cars on an adjoining track and hauled away.

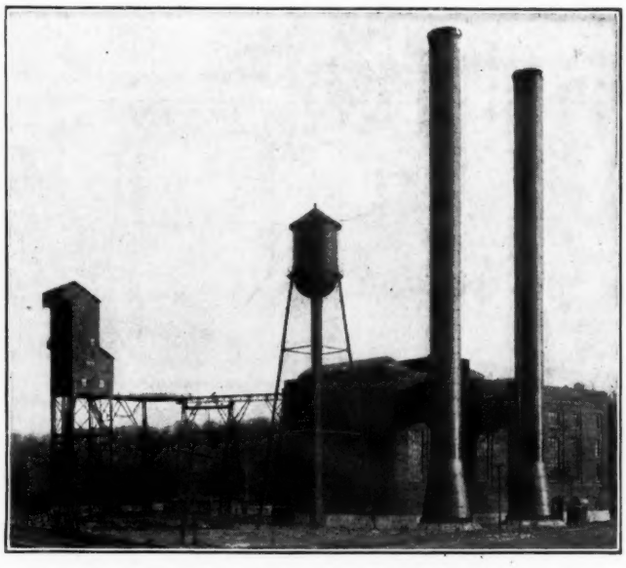


FIG. 7. EXTERIOR OF THE LOWELLVILLE PLANT

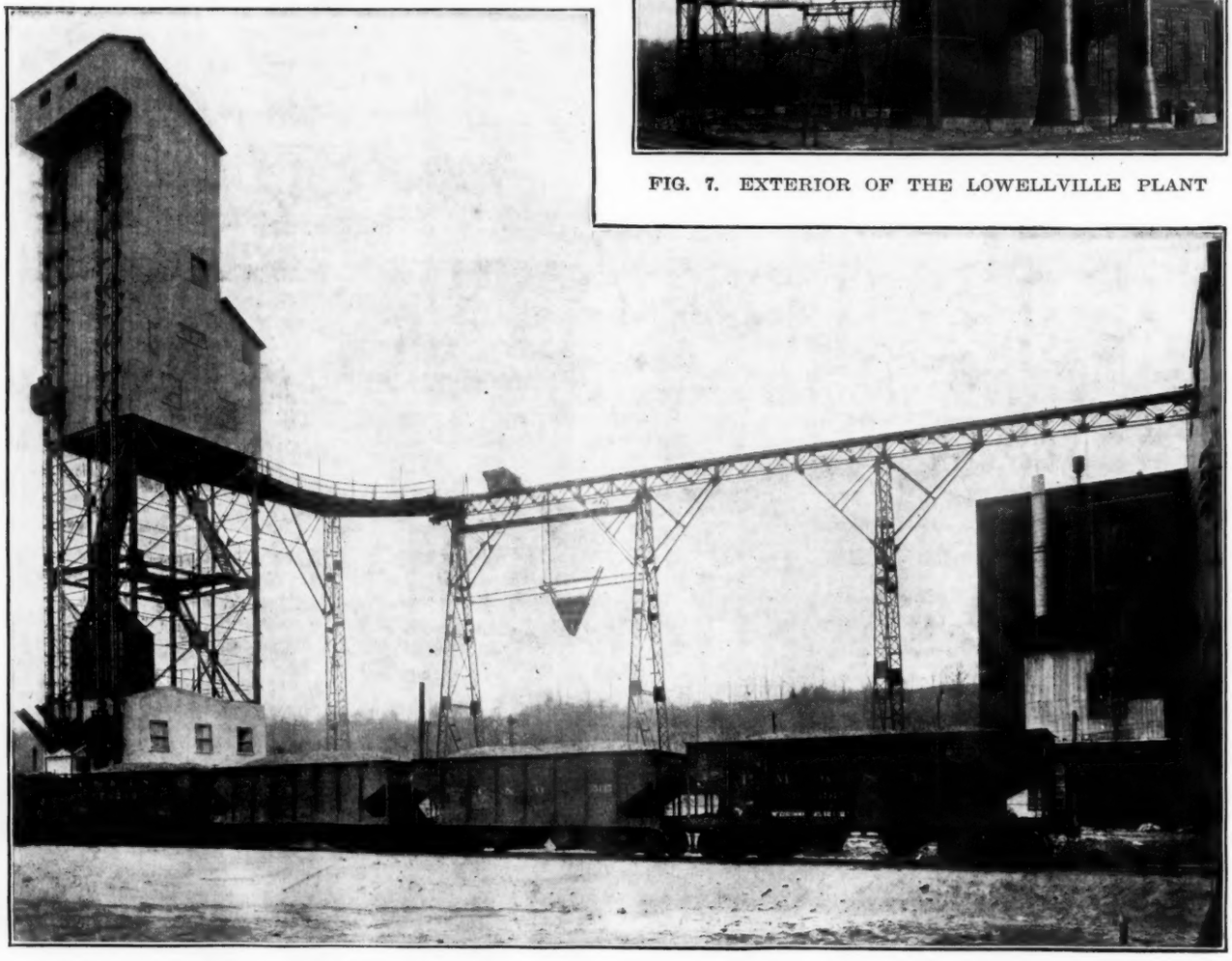


FIG. 6. ELECTRICALLY OPERATED COAL AND ASH HANDLING APPARATUS

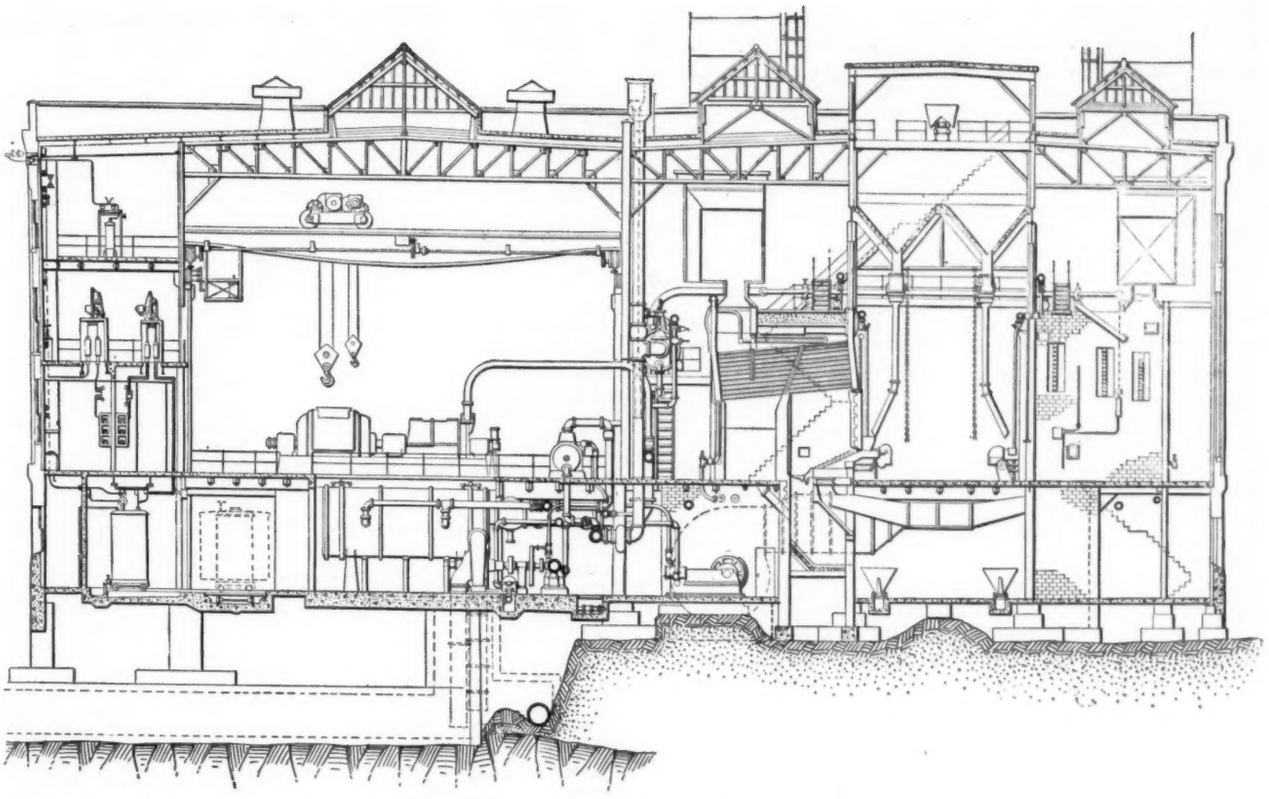


FIG 8. ELEVATION OF THE LOWELLVILLE POWER PLANT

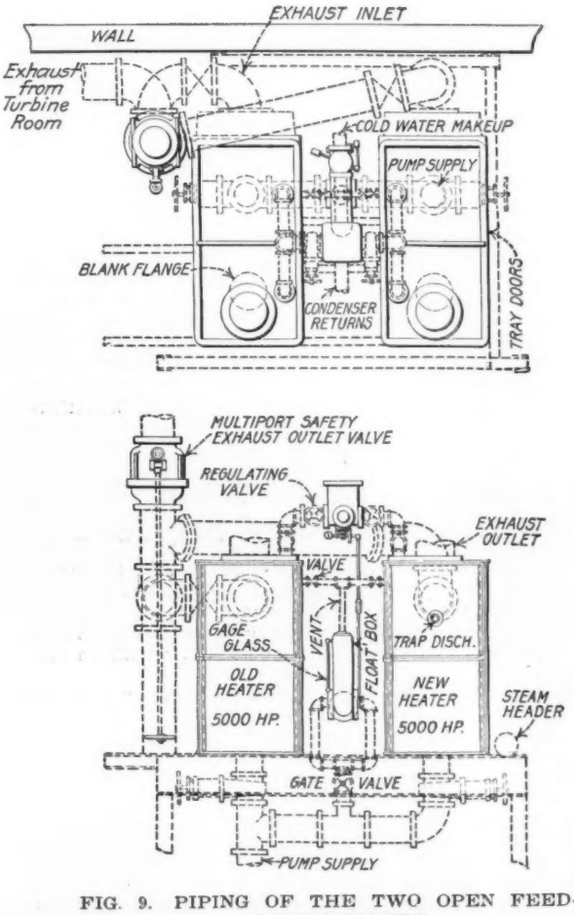


FIG. 9. PIPING OF THE TWO OPEN FEED-WATER HEATERS

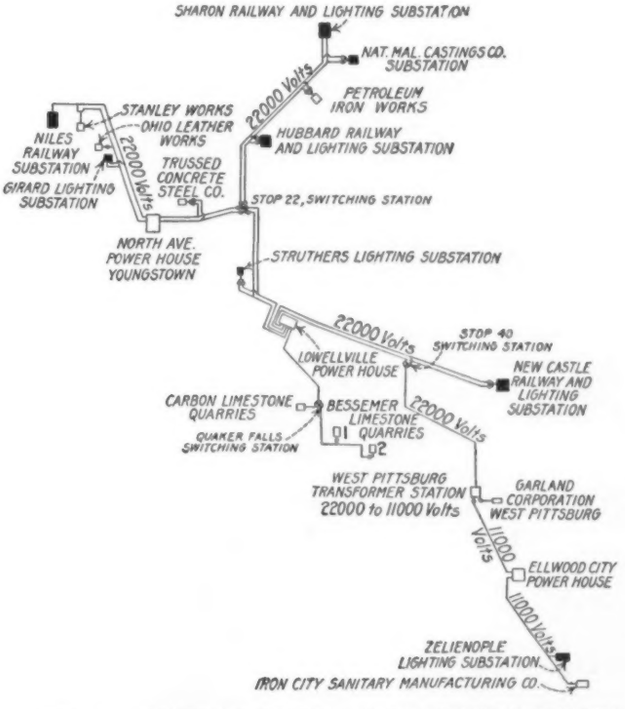


FIG. 10. DIAGRAM OF THE HIGH-TENSION SYSTEM AND LOCATION OF THE VARIOUS SUBSTATIONS

The electrical apparatus is on the opposite side of the turbine room from the auxiliary apparatus shown in Fig. 1. On the main floor is a 500-kw., 600-volt, 900-r.p.m. direct-current rotary converter for motor service. The 6-panel bench switchboard for remote control is at the end of one side of the room on a level with the turbine-room floor. The busbars are in brick compartments and are placed below the first galley, as is also the 550-kv.-a.,

2300-440-volt station transformer. On the first gallery are the remotely controlled oil switches. On the top gallery the 8 aluminum and 12 electrolytic lighting arresters are placed.

The transmission lines connecting to the North Avenue power station are two in number, both on the same poles. From this station the current is sent to substations located at suitable points. Fig. 10 shows a diagram of the high-tension system and the relative locations of the various power houses and substations. For simplicity a single line represents the three wires of each circuit. Outdoor air-break switches are so placed that certain parts of the lines or the substations may be disconnected from the rest of the system, and in some cases switches are arranged so as to make it possible to change a substation from one circuit to another, which makes the service more positive in case of trouble on any particular line.

From the Lowellville plant to New Castle the voltage is 22,000, from Stop 40 to West Pittsburgh 22,000 volts is used, and 11,000 volts to the end of that line. The voltage to the North Avenue power station is 22,000, and 22,000 volts to the Niles and Sharon substations.

PRINCIPAL EQUIPMENT OF THE LOWELLVILLE POWER PLANT, LOWELLVILLE, OHIO

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Turbo-generators	Horizontal	7500-kw	Main units	195 lb. steam, 1800 r.p.m., three-phase, 60-cycle, 2300 volts	General Electric Co.
2	Turbo-generators	Horizontal	125-kw	Exciter units	195 lb. steam, 2400 r.p.m., 125 volts	General Electric Co.
2	Pumps	Air, rotative	12x30x24-in.	With condensers	195 lb. steam, positive Corliss valve gear	Alberger Pump and Condenser Co.
2	Pumps	Volute	24-in	With condensers	18,000 gal. per min	Alberger Pump and Condenser Co.
2	Engines	Horizontal	12x15-in	Driving circ. pump	195 lb. steam, high speed	Skinner Engine Co.
2	Heaters	Open	5000-hp	Heating boiler-feed water	Multiple-unit system	Harrison Safety Boiler Works
2	Valves	Multiported		With heaters	Exhaust steam up to ½ lb. pressure	Harrison Safety Boiler Works
2	Pumps	Volute	4-in	Hotwell water	3000 r.p.m.; motor and turbine driven	Jeanesville Iron Works Co.
1	Motor	Induction		Driving hotwell pump	3000 r.p.m., 440 volts	General Electric Co.
1	Turbine	Single-stage Terry		Driving hotwell pump	3000 r.p.m., 195 lb. steam	Terry Steam Turbine Co.
2	Pumps	Volute, triplex	4-in	Boiler feed	2800 r.p.m	Jeanesville Iron Works Co.
2	Turbines	Terry		Driving boiler-feed pumps	2800 r.p.m., 195 lb. steam	Terry Steam Turbine Co.
1	Pump	Duplex	7x10x10 in.	House supply	Intermittent	Henry R. Worthington
1	Pump	Compound duplex	12&18½x8½x10-in.	House and boiler feed	Intermittent	Henry R. Worthington
4	Engines	Vertical	5½x6-in	Driving stokers	Variable-speed	American Blower Co.
1	Draft system	Canady		Draft control	Automatic	Blasidell-Canady Co.
9	Boilers	Water-tube	6000sq.ft. heating surface	Steam generators	195 lb. steam, 150 deg. superheat	Edge Moor Iron Co.
9	Superheaters	Foster		Superheating steam	150 deg. superheat	Power Specialty Co.
9	Gages	Ellison		Furnace draft	Continuous	Lewis M. Ellison
9	Blowers	Tube, Vulcan		Cleaning boiler tubes	As required	Vulcan Soot Cleaner Co.
2	Regulators	Mason		With fan engines	Automatic	Mason Regulator Co.
3	Fans	Sirocco	12-ft	Forced-draft	Capacity, two 54,000, one 60,000 cu.ft. air	American Blower Co.
2	Engines	Skinner	8x8-in	Driving forced-draft fans	Variable-speed	Skinner Engine Co.
1	Engine	Skinner	12x15-in	Driving forced-draft fan	Variable-speed	Skinner Engine Co.
1	Tower	Hunt skip	125-ton cap. per hr.	Handling coal and ashes	Intermittent, motor operated	C. W. Hunt
1	Meter	Venturi		Metering feed-water	Recording	Builders Iron Foundry
1	Crane	Traveling	40-ton	Turbine room	As wanted, motor-operated	Case Crane Co.
12	Switches	Oil		With feeder lines	Remote-control	General Electric Co.

Rules for Thickness of Wrought-Iron and Steel Pipes

In calculating the thickness required for wrought-iron pipes the following formula may be used:

$$T = \frac{0.433 \times H \times R}{45{,}000}$$

in which

T = Thickness of metal;
H = Head pressure in feet;
R = Radius of pipe in inches;
45,000 = Tenacity of wrought iron in pounds per square inch.

For wrought iron a factor of safety of 6 is sufficient; wherefore we obtain

$$T = 0.0000576 \times H \times R,$$

or, if we take the diameter D instead of the radius R, we get

$$T = \frac{0.0000576}{2} \times H \times D = 0.0000288 \times H \times D.$$

If the pressure is given in pounds per square inch the formula for thickness of wrought-iron pipes becomes

$$T = 0.0000665 \times P \times D,$$

in which P = pound pressure per square inch.

Formula for thickness of welded wrought-iron steam pipes is

$$T = \frac{D \times P}{6000}$$

in which

T = Thickness of plate in fractions of an inch;
D = Diameter of pipe in inches;
P = Working pressure in pounds per square inch.

The formula for working pressure of welded wrought-iron steam pipes, ¼ in. thick or more, is

$$P = \frac{6000 \times T}{D}$$

For finding the weight of wrought-iron pipes the formula is

$$W = 2.64\ (D^2 - d^2);\ \text{or}\ 2.64\ (D + d) \times (D - d)$$

in which

W = Weight per lineal foot of pipe in pounds;
D = External diameter of pipe in inches;
d = Internal diameter of pipe in inches;
2.64 = A constant.

THICKNESS OF STEEL PIPES—It might naturally be expected that steel pipes should be made thinner than wrought-iron pipes in proportion to the greater tensile strength of steel. Theoretically, this should be so, but in practice it can only be carried out to a limited degree. Not only is a larger margin required for safety, but the exigencies of manufacture compel a certain thickness of plate to insure making a sound weld; and the thickness cannot be reduced without risk.

P. R. BJÖRLING.

To Reintroduce Water-Power Bill at Next Congress

In connection with the water-power leasing bill passed by the House of Representatives last session, but which failed in the Senate, Secretary Lane stated recently that the bill would be reintroduced immediately upon the convening of Congress, and expressed the hope that it would be speedily passed.

As showing the necessity for such legislation to safeguard the public interest, he called attention to the rumor of the consolidation of western waterpower companies in Colorado, Utah, Idaho, Montana and Washington, which, if fully consummated, will place under single corporate control about 50 per cent. of the developed water power of the Western States. Such a consolidation, involving widely separated power plants, inter- and intrastate transmission lines, and Federal questions beyond the scope of state utility commissions, emphasizes the necessity of Federal control and regulation in the interests of the people, according to Secretary Lane.—"Engineering Record."

Five Hundred Kilowatts from Exhaust of Hoisting Engine

By Thomas Wilson

SYNOPSIS—One of the few regenerator and mixed-pressure turbine plants using successfully the exhaust from a hoisting engine. Through a reduction gear the turbine speed of 3600 r.p.m. is reduced to 720 for direct-current generator.

Less than four years ago mine No. 2 at Buckner, Ill., of the United Coal Mining Co., was opened. It was equipped to turn out 4000 tons of coal in eight hours and is now running close to capacity. The output is known

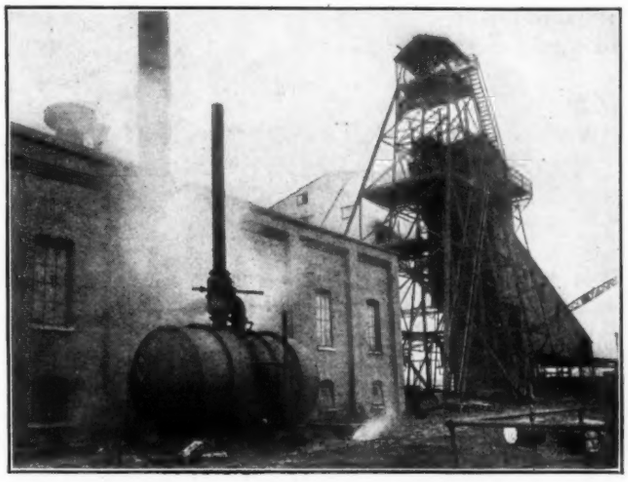


FIG. 1. STEAM REGENERATOR AT BUCKNER MINE NO. 2

as Franklin County coal and is sorted in seven different sizes from 6-in. lump to No. 5 screenings. At present the supply is taken out of one shaft 460 ft. deep. The coal is hoisted in two 4-ton cars at the rate of two cars per minute, and if necessary the rate may be increased by one-half.

The mine is worked one shift of eight hours per day. The hoisting is done by a twin engine with cylinders 28x48 in. Originally, all of the exhaust steam from this engine was blown to the atmosphere. To supply current for lighting, stationary and haulage motors and for mining machines, a 250-kw. direct-current unit and also a 50-kw. set were installed. The latter took care of the lighting and the former carried the power load. To supply these various units with steam, four 350-hp. water-tube boilers were provided. They are equipped with top-feed stokers receiving their coal from bunkers resting on the top of the furnaces; the bunkers are supplied by a screw conveyor fed from the rescreener bins. Screenings, Nos. 4 and 5, are burned. The boiler pressure is 160 lb.

Water in the vicinity was hard and contained so much incrusting and corrosive solids (the equivalent of fourteen grains of calcium carbonate per gallon) that a water softener was installed. This apparatus has a capacity of 4000 gal. per hr. The chemicals used are 98 per cent. hydrated lime and 58-test soda ash. The hardness is reduced to about three grains per gallon, and the cost of the chemical treatment averages close to one cent per 1000 gal. The water is pumped from storage ponds to an elevated tank provided for fire protection. From here it flows by gravity through the softener and to an open feed-water heater, where it mingles with the condensate and is pumped to the boilers.

Regenerator Installed

As the mine developed the load increased. The large unit was soon running at an overload, and as the tendency was always upward, more generating capacity became imperative. Woodmansee & Davidson, of Chicago, were

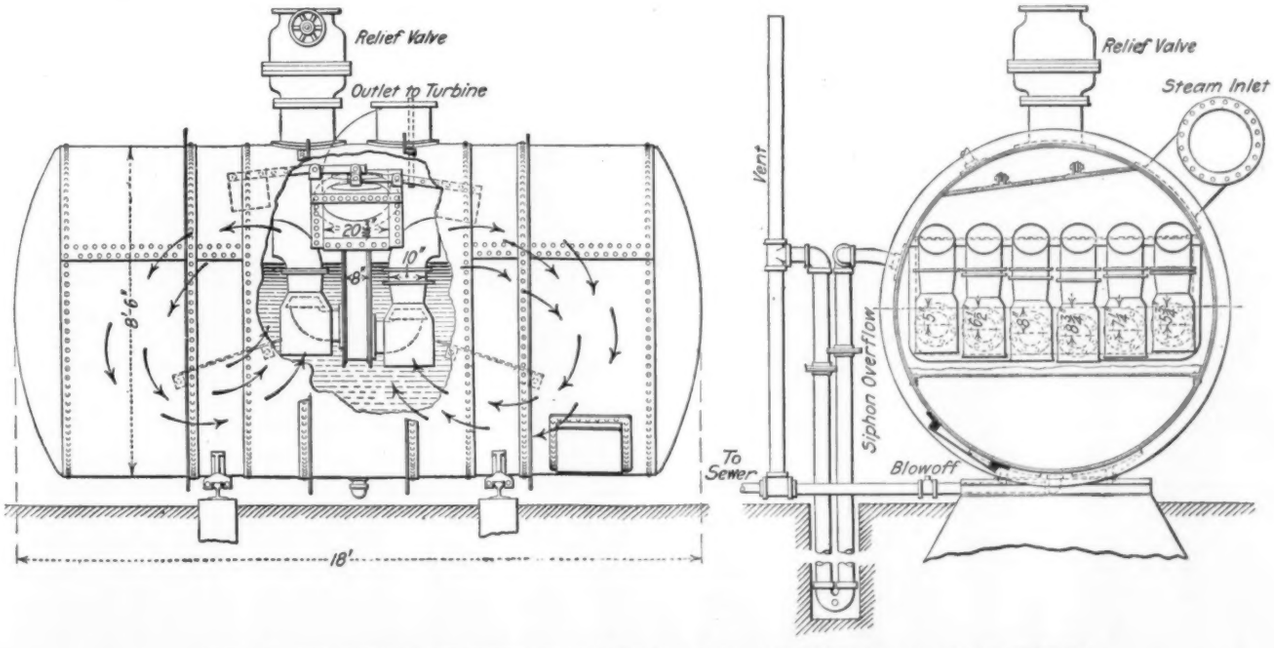


FIG. 2. THE STEAM REGENERATOR IN PART SECTION; NOTE PIPE CONNECTIONS

called in a consulting capacity, and on their recommendation a regenerator and a 500-kw. mixed-pressure turbine were installed. The former gets its steam from the exhaust of the hoisting engine, the shaker engine, a 42-hp. turbine driving the condenser pumps and, when running, the generating units previously mentioned. The load has increased so that it is necessary at times to run the largest engine unit at about half load in addition to running the turbine, Fig. 5.

Utilizing the large quantities of steam exhausted from a hoisting engine in a few seconds without imposing a back-pressure relatively heavy when compared to the av-

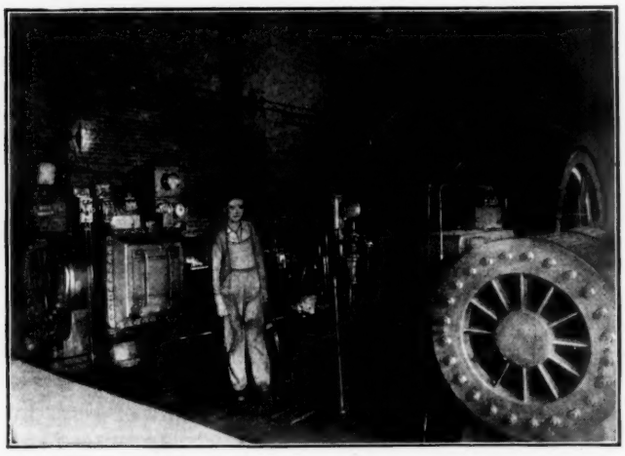


FIG. 3. TWIN HOISTING ENGINE SUPPLYING EXHAUST STEAM TO TURBINE THROUGH REGENERATOR

erage mean effective pressure is a problem requiring careful consideration. There is the chance of losing in the hoisting engine all that might be gained by the low-pressure turbine. The conditions are severe and require careful consideration to insure a net gain for the plant. The present installation is one of the few in this country operating successfully in this particular service and showing a decided saving; see Fig. 4 for arrangement of the plant.

The regenerator is one of two of a special design made by a company that has now retired from the field. A view of the apparatus working at the plant is shown in Fig. 1. Its construction will be more apparent from Fig. 2. The tank is about 18 ft. long and 8 ft. 6 in. diameter. Up to the water line indicated it will hold 18 tons of water, and under guarantee conditions utilize 1200 lb. of steam per minute. Through a 20-in. inlet the steam enters a rectangular receiving box running across the tank. From the bottom of this inclosure a rectangular distributing box projects downward into the water space of the tank, and from either side near the bottom steam nozzles project into water-legs open at the bottom and discharging above the water line toward the ends of the tank.

There are six pairs of these nozzles, and the distances of their center lines from the water level vary in ¾-in. intervals from 20 to 28¾ in. The object is to obtain an appreciable difference in head on each nozzle so that the number operating will depend on the pressure, which is controlled by the quantity of steam delivered. Between the intervals of steam admission water enters through the nozzles and rises to the level in the tank. Steam enters the inclosure, pushes down the water and discharges through the highest nozzle into the corresponding water-leg. The column of water is lightened and circulation started. Water is drawn in at the bottom and blown out at the top of the water-leg, a baffle plate forcing the circulation to continue to the end of the tank before returning to the starting point. In this way the steam is so intimately mixed with the water that it readily gives up its heat. Should the volume of steam received, and consequently the pressure in the steam space, increase, more nozzles will be forced into action until the six pairs are working. If the volume of steam is more than the regenerator can absorb, a 14-in. relief valve allows the surplus to escape to the atmosphere. In the present installation the quantity of steam is so great that the six pairs of nozzles work simultaneously, and even then some steam escapes to the atmosphere.

Means have also been provided to equalize the pressure between the inclosed steam space and the tank. With a small quantity of steam flowing, condensation may be so rapid as to create a slight vacuum in the former, while in the tank a pressure of three or four pounds may exist. The same condition might be caused by the hoisting engine when shut off and acting as a pump. Two counterweighted valves, mounted on top of the receiving box and opening downward, relieve the situation.

Data taken from the specifications will give some idea of what the regenerator is expected to do. With the relief valve set to begin to blow at 22 lb. abs. and with the water in the regenerator having been thoroughly circulated and heated and the regenerator then discharged until the pressure in the regenerating chamber has fallen to 16 lb. abs.,

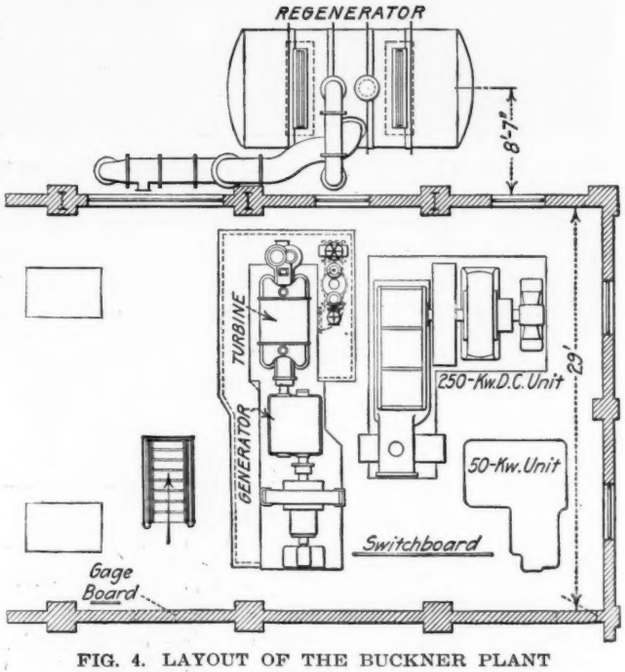


FIG. 4. LAYOUT OF THE BUCKNER PLANT

the apparatus will, with 136 lb. of steam flowing into it in 7 sec. from a hoisting engine while 45 lb. is being taken from it by a low-pressure turbine or the relief valve, absorb the remaining 91 lb. The loss of pressure through the regenerator due to the resistance to the flow of steam and the circulating of the water was not expected to exceed one pound. The total back-pressure on the hoisting engine would then be equivalent to 23 lb. abs., the regenerator itself working between 16 and 23 lb. abs., or 7 lb. It would of course operate on a lower range, but the storage would not be so great. Fig. 3 shows the engine.

The absorption of 91 lb. applies only when the maximum rate of flow of 136 lb. in 7 sec. occurs. The water capacity of the regenerator is so great that when the steam flow is less than the maximum the total amount of steam absorbed may be as much as 400 lb. This additional storage is of benefit in case of some unusual delay beyond the 13 sec. allowed as the average interval between the stopping of the hoisting engine in one run and its starting in the next.

When the regenerator was put into operation it was found that the relief valve could be set as low as 20 lb. abs., or 5 lb. gage. The "temperature head," or the difference in pressure due to the temperature of the steam and that due to the temperature of the water, is small. With the relief valve opening at 20 lb. abs., steam should be delivered from the regenerator at pressures starting at 18 lb. abs. and running down to about 13 lb. abs. At the outlet it is guaranteed not to contain more than 1½ per cent. of moisture. Fig. 6 shows the piping layout.

Safety-Valve Discharge Piped to Regenerator

In mine plants it is common to waste much steam through the safety valves on the boilers. For a few seconds the hoisting engine draws heavily on the steam supply. As soon as it is shut off the pressure begins to rise, and unless the safety valves are set considerably above the working pressure they will pop during the nonoperating intervals and waste large quantities of steam. In the plant under discussion this is what happened. To reduce the loss by recovering from this steam whatever energy the low-pressure turbine would develop, the waste steam was piped to the regenerator. A tee connection was made to the pipe supplying the hoisting-engine cylinders. Between the pipe leading out from this tee and a second pipe leading to the regenerator, two safety valves were imposed. These valves were set for a pressure slightly lower than those on the boilers, so that they would pop first and practically all the waste go into the regenerator.

Six-Stage Turbine Unit

The turbine is a six-stage double-flow machine rated at 500 kw. at a speed of 3600 r.p.m. A floating-frame, divided reduction gear, having a ratio of 5 to 1, reduces the speed to 720 r.p.m. for the generator, which is a direct-current flat compound-wound machine. As is customary in mine plants, the generators for the engine units had been overcompounded, but they were changed to conform with the new unit and to relieve the troubles that had been experienced from high voltage on the motors nearest the plant.

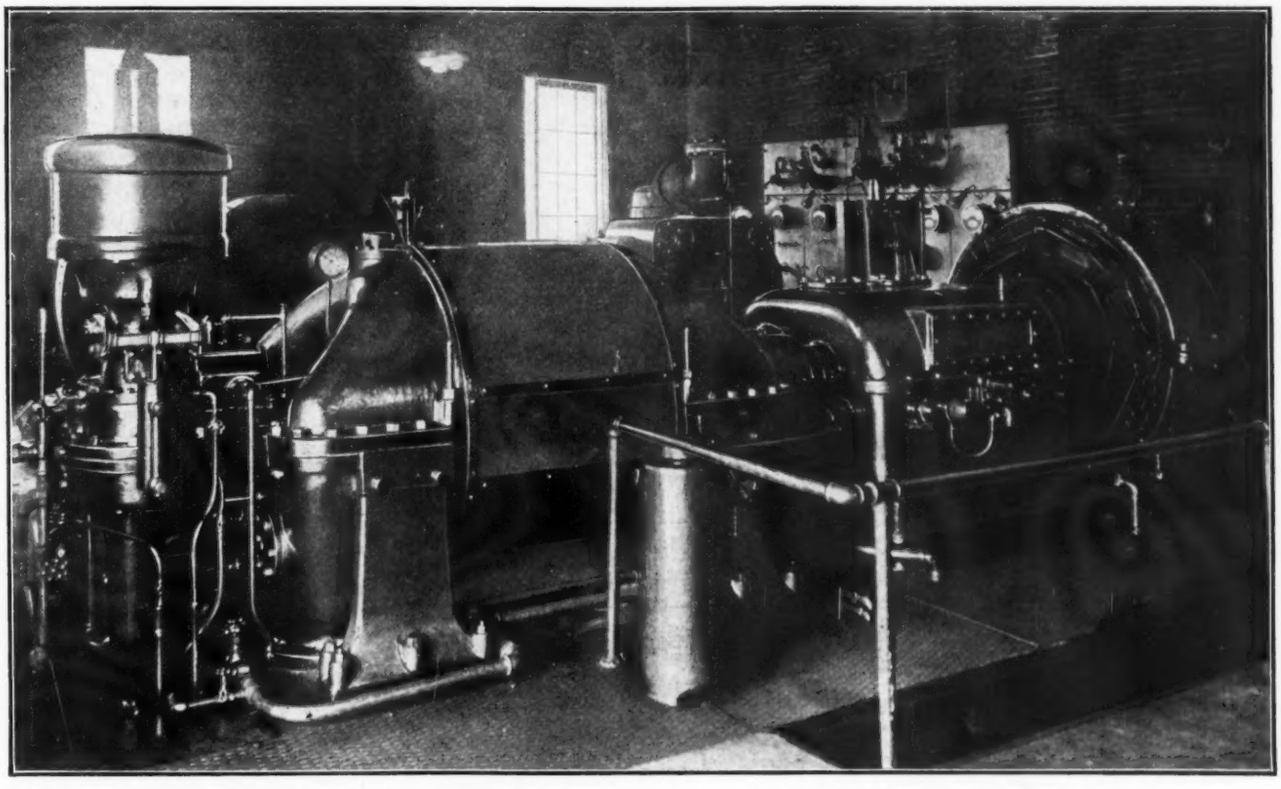


FIG. 5. THE 500-KW. LOW-PRESSURE TURBINE TAKING STEAM FROM A REGENERATOR

An improved type of jet condenser serves the turbine. It is guaranteed not to require more than 750,000 lb. of water per hour. With the water at 70 deg. F. 20,500 lb. of steam is condensed and a vacuum of 28 in. maintained. With 85-deg. water the condensation of 20,300 lb. of steam and a 27-in. vacuum are guaranteed. Thus, about 37 lb. of water to 1 lb. of steam is required. The circulating pump and a hydraulic-type air pump are mounted on a common shaft and driven by a 42-hp. turbine. The circulating pump has a capacity of 1500 gal. of water per min. (750,000 lb. per hr.) while the air pump requires 200 gal. per min., which may be recirculated. The injection water is drawn by the vacuum from a well supplied by the reservoir previously mentioned and is discharged to a smaller pond connecting with the reservoir. It must travel a considerable distance before getting back to the inlet, and the capacities of the ponds are so great that several days will elapse before the water is re-used.

In the guarantee the following steam rates for the turbine at different loads and pressures, and at 27 in. of vacuum, were given:

STEAM RATE OF TURBINE

Per Cent. Load	Throttle Pres. Abs.	Kw.	Lb. Steam per Kw.-Hr.
125	18.25	625	33.2
100	15.50	500	35.0
75	13.00	375	38.0
50	10.25	250	45.2

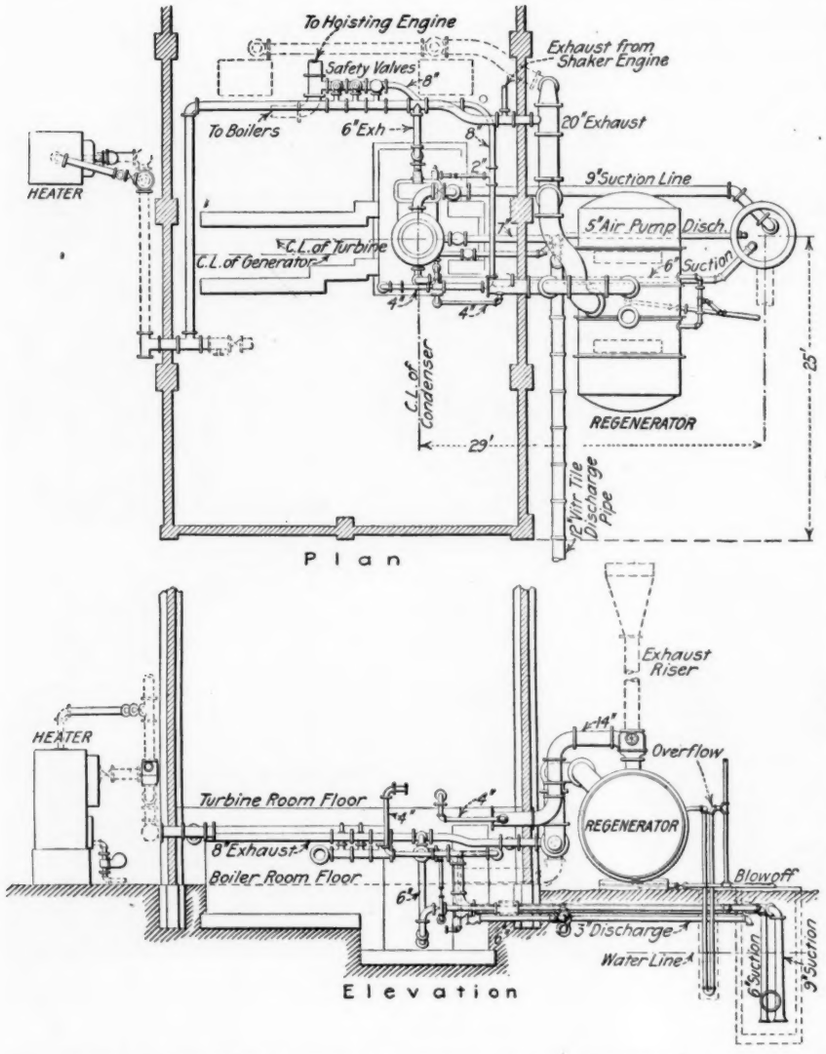


FIG. 6. SHOWING LAYOUT OF PIPING AT THE BUCKNER MINE NO. 2 PLANT

At 1¼ load the steam rate is 33.2 lb. per kw.-hr. and the hourly quantity 20,750 lb., or 115 lb. in 20 sec., made up of 7 sec. of operation and a 13-sec. interval for the hoisting engine. At normal operation and a pressure of 15.5 lb. abs. the turbine requires 100 lb. of steam in 20 sec. These figures may be compared to 136 lb., the maximum amount the regenerator will utilize.

In case the hoisting engine should be shut down and the exhaust-steam supply drop below the requirements, the turbine is equipped with high-pressure nozzles, so that steam at 150 lb. pressure will flow automatically under governor control to supply the deficiency. When the hoist is shut down, however, there is the chance that the power load may be light and that enough exhaust steam will come from other sources to supply the turbine. In fact, the turbine has run days at a time without drawing on the live-steam supply.

For the past year it is reported that the regenerator has given excellent satisfaction. The application of reduction gears has been viewed with pessimism, which has been refuted in the present installation. The gear has proved to be entirely reliable, and it runs so quietly that its presence is not made evident. Practically all of the exhaust steam in the plant is used to advantage. By imposing a back-pressure slightly in excess of what the hoisting engine already had, it is possible for the low-pressure turbine to develop a maximum of 625 kw. The electrical output of the power plant is tripled without increasing the demand for live steam. The additional steam taken by the hoisting engine is practically balanced by the steam not required by the engine-driven generating units. The small machine is shut down, and the 250-kw. unit is required only part of the time at half load. Formerly, both machines were required and the larger one was overloaded.

PRINCIPAL EQUIPMENT OF BUCKNER NO. 2 MINE PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Geary water-tube	350-hp	Generate steam	Pressure 160 lb., natural draft, stokers	Oil City Boiler Works
4	Stokers	Top-feed model	70 sq.ft.	Serve boilers		Model Stoker Co.
2	Pumps	Double water cylinder	14x8x14-in.	Boiler-feed water	160 lb. steam	National Steam Pump Co.
1	Heater	Open Cochrane	1000-hp.	Heat boiler-feed water	Exhaust steam from pumps	Harrison Safety Boiler Works
1	Coal conveyor	Screw	20 tons per hr.	Rescreening bins to bunkers		Link-Belt Co.
1	Water-softener	Cold-process	4000 gal. per hr.	Soften boiler feed		Wm. Graves Tank Works
1	Hoisting engine	Twin	28x48-in.	Hoist coal from mine	160 lb. steam, 8 to 12 tons of coal per min	Danville Foundry & Machine Co.
1	Regenerator		1200 lb. steam per min	Store steam for l.p. turbine	Relief valve set at 20 lb. abs.	American Regenerator Co.
1	Turbine	Low-pressure, six-stage, double-flow	500-kw.	Main generating unit	Operates between 18 and 10 lb. abs.	Westinghouse Machine Co.
1	Reduction gear	Floating-frame	1000-hp.	Reduce turbine speed	3600-720 r.p.m. opposed helical gear	Westinghouse Machine Co.
1	Generator	D.-c. flat compound	500-kw.	Main generating unit	250 volt, 720 r.p.m., reduced from 3600	Westinghouse Electric & Manufacturing Co
1	Condenser	Leblanc jet	20,500 lb. steam per hr.	Serves l.p. turbine	750,000 lb. of 70-deg. water per hr., vac. 28 in.	Westinghouse Machine Co.
1	Air pump	Turbine-type	200 gal. of water per min.	Serve Leblanc condenser	Driven by 42-hp. turbine	Westinghouse Machine Co.
1	Pump	Ejector	1500 gal. per min.	Serve Leblanc condenser	Driven by 42-hp. turbine	Westinghouse Machine Co.
1	Engine	Four-valve	20x24-in.	Generating unit	160 lb. steam, 200 r.p.m.	Chuse Engine & Mfg. Co.
1	Generator	Direct-current	250-kw.	Generating unit	Direct driven by Chuse engine, 250 volts	Crocker-Wheeler Co.
1	Engine	McEwen simple	10x12-in.	Generating unit	160 lb. steam, 300 r.p.m.	Ridgway Dynamo & Engine Co.
1	Generator	Direct-current	50-kw.	Generating unit	Direct driven by McEwen engine, 250 volt	Ridgway Dynamo & Engine Co.

De Laval Turbine-Driven Compressor

In the construction of the De Laval multi-stage compressor, Figs. 1 and 2, built by the De Laval Steam Turbine Co., Trenton, N. J. the casing is split horizontally permitting of the top half, or cover, being lifted off so that internal parts may be inspected and lifted out after removing the bearing caps. The impellers are mounted upon a large-diameter shaft, the critical speed of which is far above the running speed. The hubs of the wheels and impellers are attached to the shaft by keys and separated from one another by shaft-tightening rings, which run inside the split packing rings attached to the diaphragms separating the stages.

Where gases other than air are handled, double carbon rings are placed at each end of the casing in addition to the labyrinth rings surrounding the impeller suction inlet and the packing rings on the shaft. The diaphragms between stages are separate from the casing and are divided on a horizontal plane so that they may be removed without disturbing the shaft and impellers. When cooling is employed, the diaphragms are hollow, the water entering through the bottom of the casing and escaping at the top.

The impellers are of the single-suction shrouded type, and are built up on chrome-nickel steel disks, the blades, or vanes, being riveted to the disks and to side plates, turned tapering to give strength and lightness. That part of the disk which is within the circle of the suction opening is subjected on the inlet side to the suction pressure and on the back to the discharge pressure of the individual stage, which gives a resultant thrust equal to the area of the suction opening multiplied by the pressure generated.

The accumulated thrust of all the stages is overcome by a balancing disk at the discharge end, so arranged that one side receives the total discharge pressure in a direction opposite to that acting upon the impeller disk, while the chamber upon the opposite side of the balancing

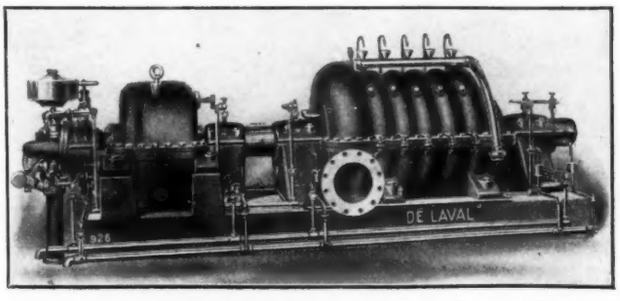


FIG. 1. SIX-STAGE CENTRIFUGAL AIR COMPRESSOR DRIVEN BY A MULTI-STAGE TURBINE

disk is connected to the suction inlet, thus neutralizing the unbalanced pressure on all of the wheels.

The head delivery characteristic can be varied considerably to meet different requirements, and with constant-speed operation is suitable for many purposes. If it is desired that the volume delivered be relatively constant, while there are considerable variations in the resistance to be overcome, as for forced draft, a steeply sloping form of head-delivery characteristic is most suitable. If the resistance to the fire should increase greatly, by reason of caking or accumulation of slag or ash, causing a diminution in the rate of flow, the pressure developed by the fan will increase sharply, loosening and lifting the fuel bed and maintaining the flow of the proper amount of air. If, on the other hand, thin spots or holes should develop, the rate of delivery of air will not increase abnormally. Similar considerations apply to other uses.

Single-stage machines are employed for pressures ranging from 4 to 6 in. water column up to 3 to 4 lb. per sq.in. The form of the head-delivery character-

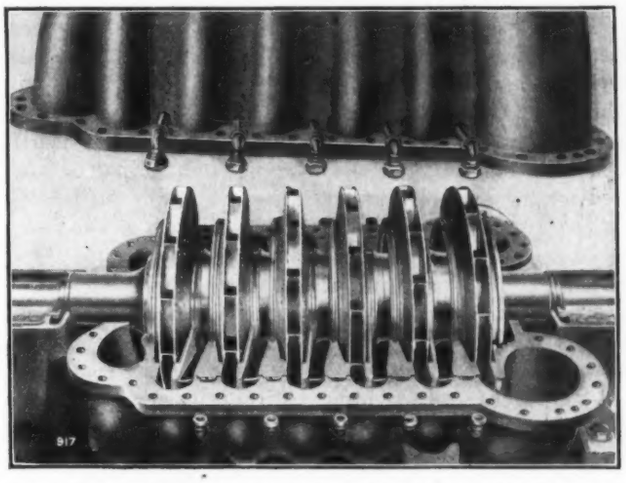


FIG. 2. INTERIOR VIEW OF MULTI-STAGE COMPRESSOR WITH CASING COVER LIFTED

istic can be modified according to the work to be done. In supplying forced draft to boiler furnaces, for instance, a steeply sloping head-delivery characteristic is advantageous, since it insures a relatively constant delivery of air through the fire, corresponding to the speed for which the turbine, governor or driving motor may be set, hence, a constant rate of combustion irrespective of the varying conditions and resistance of the fuel bed. By driving both stoker and fan from the same source of power, the rates of delivery of fuel and air can be kept at the correct proportion.

Drains for Steam Pipes should be provided at all points where it is possible for water to accumulate. Some may be for use only when putting the line into service, but are necessary at such times. Drains from points where there is even slight difference in pressure should not be joined together or to the same trap, as the difference will prevent the proper operation of the one of lower pressure. If, however, a still lower pressure or constant discharge is maintained beyond the point of junction, as in the Holley loop, the foregoing does not apply.

Boiler Accidents in France in 1912—An official compilation on 28 accidents gives the types of apparatus and the corresponding number of accidents as follows: External furnace, horizontal nontubular boilers, 5; internal furnace, vertical nontubular, 1; external furnace, semitubular fire-tube, 1; direct-fired internal furnace, 2; return-fired internal furnace, 2; water-tube boilers, 7; superheaters, 1; thermo-siphon, 1; water-gage glass, 2; blowoff cock, 1; safety valve, 1; vessels, 4. The supposed causes of these accidents were: Lack of care in shell-case riveting, 1; defective tubes in semitubular boilers, 1; loose covers, 4; defective welding of superheater case, 1; defective welding of steam collector, 1; old age, corrosion, 4; splitting of rivet holes, 1; overheating caused by scale, 3; excessive pressure due to clogging of valve passages, 1; overheating, lack of water, 2; overheating, cause unknown, 1; excessive pressure, 1; improper management and attendance, 3; breakage of water gage-glass, 3; breakage of blowoff-valve case, 1; weakness in locomotive boiler, 1.—Foreign Exchange.

Rewinding Direct-Current Motors and Generators--III

By A. A. Fredericks

SYNOPSIS—Calculations and directions for rewinding a 120-volt machine for 240 volts; also for changing a series motor to shunt wound.

The windings on two-pole machines cannot be connected to meet so many conditions as four-pole, and where they are to be reconstructed to work on a different voltage than that for which they were designed, it is often necessary to rewind both the field and the armature. This is because there is only one type of winding that can be used on the armature and two ways that the field coils can be grouped, whereas the field coils on a four-pole machine can be grouped in three ways, namely, series, series-parallel and parallel; and the armature windings may be connected either in series or in parallel.

For example, let it be desired to rewind a two-pole 2-hp. 120-volt machine for 240 volts, assuming that each coil in the 120-volt winding has four turns of No. 16 B. & S. copper. Since the working voltage is to be doubled, and as the armature cannot be reconstructed to meet this condition the coils will have to be rewound with double the number of turns, and to get the winding in the same space as before the cross-section of the copper will have to be halved. Therefore, rewind the coils with eight turns of No. 19 B. & S. This will increase the armature resistance four times, which at first thought may be considered wrong, but an investigation will show that it is not.

Assume the length per turn in each armature coil to be 27 in. with a total of 50 coils; which will make 25 coils in series per path through the armature. Then the total length of copper per path in feet will equal the length per turn in feet, multiplied by the turns per coil, multiplied by the number of coils in series. On the 120-volt machine this will equal $2.25 \times 4 \times 25 = 225$ ft.

The resistance per circuit through the armature equals the resistance per foot of copper multiplied by the total length in feet. By referring to the wire table given in Part II (July 27 issue) it will be found that No. 16 B. & S. copper has a resistance of 4.009 ohms per 1000 ft. or 0.004009 ohm. per ft. Then the resistance of one path through the armature of the 120-volt machine will be $225 \times 0.004009 = 0.902$ ohm. In the table is given the

AVERAGE EFFICIENCIES OF DIRECT-CURRENT MOTORS OF VARIOUS SIZES

Output of Machine in Horsepower	Per Cent. Commercial Efficiency	Output of Machine in Horsepower	Per Cent. Commercial Efficiency
⅛	70	10	86
½	75	20	88
1	78	30	89.5
2	80	50	91
3	82	100	92
5	84		

commercial efficiency of various sizes of direct-current motors, and the full-load currents may be calculated from the formula,

$$I = \frac{Hp. \times 746 \times 100}{E \times \textit{per cent. efficiency}}$$

I is the full-load current in amperes, Hp the rated horsepower as marked on the nameplate, and E the voltage for which the motor is designed. From the table it will be seen that the commercial efficiency of a 2-hp. motor is 80 per cent.; then full-load current is

$$I = \frac{2 \times 746 \times 100}{120 \times 80} = 15.5 \textit{ amp.}$$

Since the machine has but two poles there can be only two paths through the winding; therefore, there will be

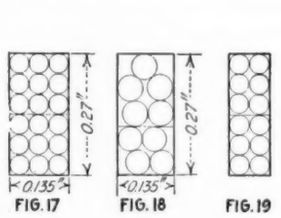


FIG. 17

FIG. 18

FIG. 19

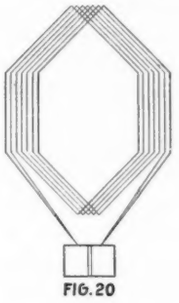


FIG. 20

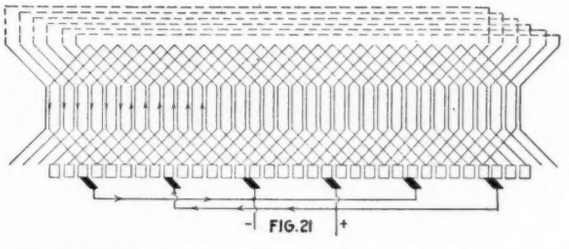


FIG. 21

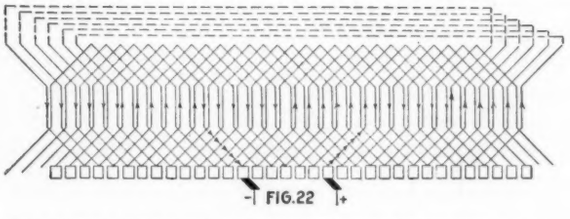


FIG. 22

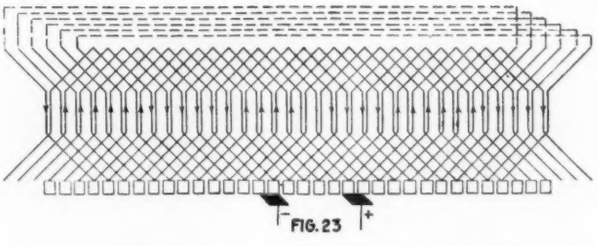


FIG. 23

$15.5 \div 2 = 7.75$ amp. per path at full load. The watts loss (I^2R) per path equals the square of the current multiplied by the resistance per path $= 7.75 \times 7.75 \times 0.902 = 54.18$ watts, and the total watts lost in the armature copper will equal the watts lost per path multiplied by the number of paths, or $54.18 \times 2 = 108.36$ watts. This represents the heating effect of the current in the armature conductors of the 120-volt machine.

The 240-volt winding must meet this condition and, since the number of turns per coil have been doubled, the total length of copper per circuit will be doubled and will equal $225 \times 2 = 450$ ft. From the wire table it will be found that No. 19 wire has a resistance of 8.038 ohms per 1000 ft., or 0.008038 ohm per ft.; whence

the resistance per circuit will be 450 × 0.008038 = 3.617 ohms, or approximately 4 times that on the 120-volt machine. The full-load current is $I = \frac{2 \times 746 \times 100}{240 \times 80}$ = 7.75 amp. The current per path will be $\frac{7.75}{2}$ = 3.875 amp. Then the watts lost (I^2R) per path = 3.875 × 3.875 × 3.617 = 54.3, and the total watts lost in the armature copper = 54.3 × 2 = 108.6 watts against 108.36 for the 120--volt machine.

Another thing to be considered is the average voltage drop between the commutator segments. This should not exceed 7 volts on a 110-125-volt machine, 10 volts on a 220-250-volt machine and 15 volts on a 500-550-volt machine. The last value may be increased for small machines, but in no case should it exceed 25 volts. If the average drop between the segments is too high there will be danger of flashing over.

In the problem under consideration there are 50 coils in the armature, consequently 50 segments in the commutator; the number of segments divided by the number of poles giving the number of segments between brushes, in this case 50 ÷ 2 = 25. For a 110-volt machine the average drop between segments is 110 ÷ 25 = 4.4 volts, which is well within the limit. On a 220-volt machine the average drop will be 220 ÷ 25 = 8.8. This should give satisfactory results. On the 500-volt machine the average voltage drop will be 500 ÷ 25 = 20 volts. For small machines this value should give satisfactory results.

In 6-pole armature windings more difficulty may be experienced in changing from one standard voltage to another than in the 4-pole machine, as the ratio between the parallel and series winding is 3 and not 2, as in the 4-pole machine. This will be understood by referring to Figs. 21 and 22. In Fig. 21 is shown a 6-pole parallel winding of 34 coils and, as will be seen by tracing out the circuit through the winding, there are 6 paths of approximately 6 coils in series in each path. In Fig. 22, which is the same winding as in Fig. 21 connected series, there are only two paths with 17 coils in series in each path, or approximately 3 times that in the parallel winding.

If it were desired to change the winding of a 125-volt or a 250-volt 6-pole parallel-wound armature (as in Fig. 21) to work on 250- or 500-volt circuits respectively, unless the coils were wound with two conductors in parallel (as shown in Fig. 6, Part I, July 20 issue, or Fig. 20) the double-voltage condition could be met by connecting the two parallel circuits in each coil in series (as in Fig. 7, Part I), otherwise the only way to meet the double-voltage requirements would be to rewind the armature coils with double the number of turns of one-half the cross-section. If the conditions to be met were opposite to the foregoing, say from 500 to 250 volts, in all probabilities the 500-volt winding would be single-series connected as in Fig. 22, and changing to double series as in Fig. 23 would meet the 250-volt requirements. The field coils can be connected series-multiple as in Fig. 13, Part II (July 27 issue), in which case there will be three coils in series in each group instead of two.

When rewinding an armature for a lower voltage, say from 250 volts to 125 volts, it may be found difficult to obtain the proper number of turns per coil. For instance, take a 250-volt winding having 9 turns per coil of No. 19 B. & S. double, cotton-covered wire arranged in a winding as in Fig. 17. By referring to the wire table it will be seen that the outside diameter of this wire is 0.045 in. Then the winding space required in the slot is as shown, namely, 0.135x0.270 in. To rewind this armature for 125 volts will require rewinding the coils with one-half the number of turns with copper double the cross-section, or 4.5 turns per coil of No. 16 copper, which has a cross-sectional area of 2583 circ.mils against 1288 circ.mils for No. 19. It is impossible to have a half-turn in an armature coil, but this problem may be solved by winding one-half the coils with an extra half-turn, or 5 turns per coil, and the other half with a half-turn less, or 4 turns per coil. This would make an arrangement in the slots as shown in Fig. 18. The diameter of No. 16 double, cotton-covered

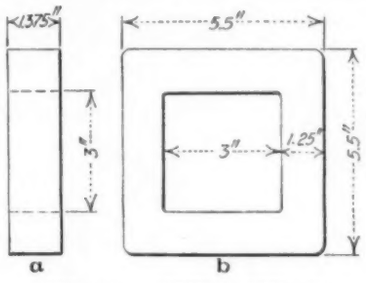


FIG. 24. GIVING COIL DIMENSIONS

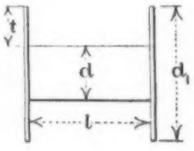


FIG. 25. CORE DIMENSIONS

wire is 0.060 in., and the space occupied by the new winding will be 0.12x0.3 in., which is 0.015 in. less in width and 0.03 in. greater in height than the 250-volt winding. However, if the conductors are staggered as shown they will easily fit in the same space that the original winding did. If there is an odd number of coils in the winding the odd coil should be wound with the small number of turns.

Fig. 19 represents the cross-section of an armature slot where the coils are wound with 6 turns of say No. 14 B. & S. double, cotton-covered wire. To change this winding over for half-voltage would require rewinding the coils with 3 turns of double the cross-section of a No. 14, which is No. 11. The winding space occupied by the coils wound with six turns of No. 14 is 0.150x0.45 in. Winding the coil with No. 11 wire would be difficult on account of the poor arrangement of the conductors in the slots which can be only one wide, and on this account it would be difficult to get them in the allotted space. A better way would be to rewind the coils with two No. 14 wires in parallel, as shown in Fig. 20. This would give the same arrangement of conductors in the slot as in the 250-volt winding with one-half the number of turns in series.

Now consider the problem of rewinding the field coils of a series motor so that it may be connected shunt and run at the full-load speed of the series machine. Take a ½-hp., 115-volt, 2-pole machine. The first thing to be done is to determine the field current. In the series motor the field coils are connected in series with the armature, therefore the field current will be the full-load current of the machine. This may be obtained from the nameplate, or from the formula,

$$I = \frac{Hp. \times 746 \times 100}{E \times per\ cent.\ efficiency} = \frac{0.5 \times 746 \times 100}{115 \times 75} = 4.3\ amp.$$

Next, obtain the dimensions of the field coils and the number of turns. Assume the dimensions of the coil

to be as shown in Fig. 24. The number of turns on the field coils of a series motor can usually be obtained most easily by counting, and in this case assume that each one of the coils contains 178 turns of No. 12 wire, making a total of 356 turns on the two coils, then the ampere-turns on the two field coils $= IT = 4.3 \times 356 = 1530$. The average length per turn equals the length of the inner periphery of the coil plus 4 times the thickness, or in this problem, $12 + 4.5 = 16.5$ in.

The cross-section of the wire required for the shunt coils may be found by the formula,

$$Circ.mils = \frac{10.8\, l\, I\, T}{12\, E};$$

where l is the mean length per turn in inches, IT the ampere-turns and E the line voltage. Substituting, the area is

$$\frac{10.8 \times 16.5 \times 1530}{12 \times 115} = 197\ circ.mils.$$

By referring to the wire table it will be found that this is approximately the cross-section of a No. 27 wire (No. 27 having 201 circ.mils). Therefore, the field coils will be rewound with No. 27 single, cotton-covered wire.

In small shunt machines the field current amounts to about 6 per cent. of the total full-load current, or in this problem is 6 per cent. of 4.3 = 0.26 amp. The resistance of the field coils R will equal the impressed voltage E divided by the field current I, or $115 \div 0.26 = 442.3$ ohms. In the wire table in Part II it will be found that No. 27 single cotton-covered wire has a resistance of 77.462 ohms per pound. Then the total weight in pounds on the two field coils will equal the total resistance divided by the resistance per pound, or $442.3 \div 77.462 =$ 5.8 lb. Therefore, each field coil will be rewound with 2.9 lb. of No. 27 single, cotton-covered wire. The total length of wire used equals the feet per pound (which for No. 27 in the wire table is 1510) multiplied by the total weight in pounds, or $1510 \times 5.8 = 8758$ ft.

For a square core the outside diameter of the coil may be found from the formula,

$$d_1 = \sqrt{\frac{12\, X^2\, L + l d^2}{l}},$$

where X is the outside diameter of the wire in inches (for No. 27 single, cotton-covered, 0.0187); L is the total length of wire in feet wound on the coil $= \frac{8758}{2}$, and l, d and d_1 are respectively the length, inside diameter and outside diameter of the coil as shown in Fig. 25.
Then,

$$d_1 = \sqrt{\frac{(12 \times 0.0187 \times 0.0187 \times 4379) + (1.375 \times 3 \times 3)}{1.375}}$$

$$= 4.73\ in.\ outside\ diameter.$$

The thickness of the coil will be $t = \frac{d_1 - d}{2} = \frac{4.73 - 3}{2} = 0.87$ in. This is on the assumption that the coil has square corners, is wound in layers, and that each wire occupies a square space one side of which is equal to the outside diameter of the wire. But in actual practice for small wire it is about 25 or 30 per cent. more. This will bring the thickness of the coil up to about 1.1 in., which is about the same as that for the series winding.

The watts W expended in the coils equals the square of the current I multiplied by the resistance R, or $W = I^2R = 0.25 \times 0.25 \times 442.3 = 28.9$ watts. This energy heats the coils and must be dissipated as fast as it is generated, or the coils will become too hot and destroy the insulation. It is difficult to calculate the rate at which heat can be dissipated from any coil, but 0.75 watt per square inch of cylindrical surface is usually a safe value for shunt-field coils where the ventilation is good. This is for a rise in temperature of 75 deg. F. above the surrounding air. Taking the outside diameter of the coil as 5.5 in. and the length as 1.375 in., as in Fig. 24, then the cylindrical surface of the two coils will be $5.5 \times 4 \times 1.375 \times 2 = 60.5$ sq.in. The watts expended in the field coils divided by the cylindrical surface in square inches gives the watts to be dissipated per square inch $= \frac{28.9}{60.5}$ $=0.478$ watts, per square inch, which is well within the limit.

After the size of the wire for the shunt winding has been determined by the formula, circ.mils $= \frac{10.8\, l\, I\, T}{12\, E}$, rewinding the field coils with the same weight of wire as on the series field winding should give fairly satisfactory results for the shunt machine.

Suction Lift for Pumps

By David Fliegelman

Water-works specifications are often drawn up calling for pumps to operate successfully on 21-ft. suction lifts. This article may be of benefit to those interested in the operation of steam and power pumps, and its purpose is to show that a 20-ft. suction lift is all that should reasonably be expected with the standard types of reciprocating pump. To be sure, a large number of pumps are operating on much higher lifts than 20-ft., but this is owing to special design or else the pumps are doing better than is to be expected.

In considering this question it must be remembered that practical considerations limit the suction lift. These are chiefly three—the clearance at the end of the stroke,

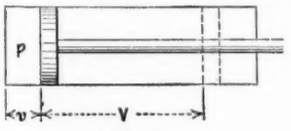


FIG. 1

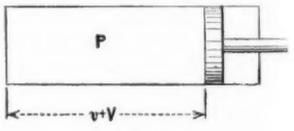


FIG. 2

the pressure required to lift the valve off its seat and the friction to be overcome.

In most of the commercial stock pumps the clearance is about twenty-five per cent.; the pressure required to lift the valves off their seats is 2 lb. per sq.in. of valve opening; and the loss due to friction in the suction pipe and cylinder ports amounts to ½ lb. per sq.in. At the beginning of the stroke there is the clearance v, Fig. 1, filled with air at a pressure p, which will be above atmospheric pressure by the amount necessary to lift the discharge valves and to overcome friction. Assuming the atmospheric pressure to be 14.7 lb. per sq.in. absolute, we have

$$p = 14.7 + 2 + 0.5 = 17.2\ lb.\ abs.$$

When the piston has reached the end of the stroke, as shown by Fig. 2, it has displaced a volume equal to V

and the air originally occupying volume v has expanded to fill a volume equal to $v + V$. But since v represents the clearance and equals 25 per cent. of V, $v + V = 5v$. In other words, the air originally in the clearance has expanded to five times its original volume and, consequently, its pressure has been decreased by 5, since by Boyle's law pressure times volume equals constant. Therefore,

$P = \frac{1}{5}\ p$, $p = 17.2$ *lb. abs., and* $P = 3.44$ *lb. abs.*

the atmospheric pressure is in excess of the pressure in the cylinder by

$$14.7 - 3.44 = 10.26 \text{ lb. per sq.in.}$$

but 2½ lb. per sq.in. is required to lift the suction valves and to overcome friction, leaving 8.76 lb. per sq.in. available for lifting water in the suction pipe; 8.76 lb. per sq.in. is equivalent to a head of water 20 ft. high. since atmospheric pressure, 14.7 lb. per sq.in., will support a column of water about 34 ft. high, it would seem that 14 ft. of the water column is lost in overcoming the resistances due to design and construction. The problem cited is worked out on the assumption that the pump has not yet primed.

If there is water in the cylinder the clearance volume at the beginning of the stroke may be only partly filled with air or may contain no air at all. In this case the pressure P at the end of the stroke will be less than 3.44 lb. per sq.in. and, in consequence, the pump will lift water by suction over 20 ft., possibly 30 ft.; hence the advantage to be gained by priming a pump when first started.

A study of the problem will tend to show that it may be possible to increase the suction lift of pumps by decreasing the clearance or by decreasing the pressure required to lift the valves off their seats. With large pumping engines of the crank and flywheel type the clearance can be made a minimum, since the stroke is positive. The same holds true for reciprocating power pumps. In case of direct-acting steam pumps where the stroke is not fixed, ample clearance is required in the design. But no matter what type of reciprocating pump is considered, it is impossible to do away with the port passages between the cylinders and the valve chambers, so that every pump must have some clearance.

To decrease the pressure required to lift the valves, it may be suggested to use thinner or lighter valves or lighter springs. Since most pumps are used to operate against heavy pressures or to handle hot water or, possibly, some heavier or thicker liquid than water, it is generally preferable to fit the pump with suitable heavy valves and springs. The problem is worked out for cold water, which does not easily vaporize when the pressure of the atmosphere is reduced. However, when handling water at 100 deg. F. or hotter, the maximum suction lift becomes smaller, since the liquid rapidly vaporizes as the pressure falls. With water at 200 deg. F., no suction lift is possible and it is necessary for the water to come to the suction of the pump under a head. For the same reason, pumps handling hot liquids should operate at slow speeds to prevent the evaporation of the liquids in the cylinders and valve chambers, and thus cause the pump to become vapor-bound.

With centrifugal pumps the design and construction are such that the confined air in the suction line cannot be removed by operating the pump. It is, therefore, essential in every instance to prime a centrifugal pump.

JUST FOR FUN

This Belongs in This Column

In the "Just for Fun" column of your issue of July 6, I wonder if C. E. Buncome, or Bascom, as he calls himself, realizes that the arrangement of piping shown there would balance the piston and therefore the engine would not run at all.

You might have an engineer to edit this particular column once in a while to see that it is really funny and not foolish.—J. Aleck York, Longueuil, Montreal, Canada.

[It would if the exhaust pipe were not larger than the drip pipe. Take another think!—Editor.]

A Fine Labor-Saving Idea

Looking over some of the "bone-head" stunts in the "Just for Fun" column reminds me of one pulled off by a fireman I once had on a 40-hp. portable boiler on road work. One evening, after blowing down, I left word for the fireman to fill the boiler and get up steam in the morning. On arriving, I found 30 lb. of steam, a hot fire, no water in sight and the fireman trying to start the injector. I pulled the fire in a hurry and got away to await developments, but fortunately, no explosion occurred, although the sheets and tubes were red-hot. The explanation given was that the hand pump had broken, so the boiler had to be filled with pails of water carried from the stream. He said he had just put in enough water to get up steam and intended to fill 'er up with the injector.—W. P. Humphrey, Elizabeth, N. J.

A "Purposeful Anecdote"

I am not writing this "Just for Fun" or to ridicule, but to emphasize the danger of having inexperienced helpers. We were installing a 1200-hp. capacity feed-water heater with two inexperienced helpers. Certain parts and fittings came in a large wooden case packed with excelsior, and as we had no coke or other filtering material on hand we decided to use excelsior for a time in the filtering chamber. The helper was instructed to put the excelsior on the grates (bottom of filtering chamber) and then to clean up while the erecting man was away on an errand.

"Where will I put the case?" asked the helper.

"Break it up and put it into the furnace," meaning one of the boiler furnaces.

On returning the erecting man was met by his helper who said, "I don't think we can work in there now, because there is too much smoke in the pump room."

"Why, where is the smoke coming from?"

"I put the excelsior into the little firebox and broke the case and put it on top, but I had quite a lot of trouble to put it all in, as this firebox is not as big as the one under the big boilers. I have been trying to fire up, but it won't burn good."

Having heard that the new rig was to heat the water before it went to the boilers, the helper had taken it for granted that it was some kind of boiler unknown to him and that the filtering chamber with its grates was a firebox, so he started the fire in order to give the firemen hot water for the boilers. Fortunately, no damage was done.—Benjamin J. Rendov, Nordegg, Alta., Canada.

Reducing Smoke in Pittsburgh

By J. W. Henderson*

SYNOPSIS—Pittsburgh, synonymous with the smoke question, has recently made several changes in its smoke ordinances and during the last year has accomplished commendable results in smoke abatement.

Since Mar. 4, 1913, the City Council of Pittsburgh has passed several ordinances relating to the regulation of the production and emission of smoke and to the office created for that purpose. Ordinance No. 257 contains new features not found in the restrictions in smoke ordinances of any other city. The smoke limits were changed from 8 min. in one hour for all stacks, to 1 min. in any period of 8 min. for locomotives and steamboats, and 2 min. in any period of 15 min. for all stationary stacks.

In 1914 about 20,000 "Cleaning-Up" cards, showing the Ringelmann scale for smoke density and stating the provisions of the ordinance, were distributed at luncheons and meetings by clubs and societies, in department stores and to the membership of the Chamber of Commerce.

On Apr. 8, 1915, the Chamber of Commerce adopted a report and set of resolutions presented by its smoke-abatement committee from which the following paragraph is quoted:

Resolved, That a sufficient time having elapsed to allow everyone to become familiar with all phases of the smoke question as well as to provide suitable apparatus, this Chamber urges the Bureau of Smoke Regulation to begin a vigorous enforcement of the law by prosecuting promptly all offenders against the very lenient laws now in force; and we assure the Bureau that such enforcement will have our hearty endorsement and support.

Most locomotives operated in the city have been brought into compliance with the law. A year ago, hardly 1 per cent. of the locomotives fired and ready for service, or actually in operation, were complying with the law. At this time, and for several months past, fully 99 per cent. are doing better than keeping within the law. The total number of locomotives to which these remarks apply is 1190 daily average. Railroad officials acknowledge that economies in fuel and in upkeep costs are the result of smoke abatement efforts.

The experience of the Crucible Steel Co. of America is interesting. Figs. 1 and 2 show the company's stacks. Fig. 1 was taken several years ago, and the other on May 27, 1915. The eight stacks shown are those from the 4800-hp. boiler capacity referred to in the annual report quoted here. The stacks emit but a slight blue haze and no smoke such as mentioned in the ordinance.

The following is quoted from the thirteenth annual report of the Crucible Steel Co. of America:

To do away with the smoke evil, to save labor and make the fuel consumption the more effective, we have endeavored to put into use such mechanical devices as will produce the best steam economies. Here we have scrapped an old plant of 55 boilers located on valuable land leased by your company for many years, in which boilers the insurance companies would allow a pressure of but 85 lb., and have replaced them with eight 600-hp. units, having double the steam pressure of the old boilers, and with mechanical stokers. These eight boilers cost, with boiler house, coal and ash-handling apparatus, including every mechanism known to produce an uptodate plant, but $130,000.

This new installation is saving $1500 per month in payroll and $3500 per month in coal, equal to $60,000 per annum, or 6 per cent. on $1,000,000. In addition, it has increased the capacity of the whole mill through a greater steam supply.

This statement is signed by the chairman of the Executive Committee and by the president of the company.

The boiler capacity and the number of stacks referred to constitute but a small part of the total at all the Crucible Steel Co. plants in Pittsburgh.

Incidents comparable with that of the Crucible Steel Co. are quite general, but I will confine myself to data furnished by the officers of two well-known buildings in Pittsburgh. The following is from a bank building:

We installed stokers, and the cost of coal and labor incident therewith was $6082.53. Assuming that we would have burned gas in that year, at the new rates the cost would have been $9254.25. Comparing these figures with those of the coal consumption, we have saved $3171.72, or practically more than the cost of the stokers.

This was received from an office building:

In the winter of 1903 we installed four stokers under four 200-hp. boilers at a cost of between $4000 and $5000, including the automatic control, air piping, blower engine and blower. Our average cost of upkeep to and including December, 1914, covering all repairs and replacements in connection with the stoking system, has been 2.79 per cent. on the original cost of installation.

During the fiscal year preceding the installation of our stokers, our coal consumption was 171,010 bu., while in the year following, with the same steam requirements, it was 141,901 bu.—a saving of 1106 tons, or 17 per cent.

The condition shown in Fig. 3 weakens the argument that freedom from smoke is due to hard times and idle plants. Here the blast furnace was to be started in July, 1914, in which case the smoke conditions could easily be as shown in Fig. 4 on account of then having blast-furnace gas as fuel. The boilers are equipped for gas fuel and not to use coal. The blast furnace was not started until March, 1915. The boilers, of 3400 hp. total, having 12 stacks, were operated almost smokelessly, as shown in Fig. 4, by the addition of steam-jet air siphons.

A change to practically smokeless operation, as shown in Figs. 5 and 6, was made by merely admitting more air at the proper place in the arches over inclined grates. At this plant there are 15 boilers of 5963 hp. total.

There are many plants each having a number of boilers connected to one or more stacks representing, even in the case of a single stack with several thousand boiler horsepower, continuous smokeless operation. During the past year progress in smoke abatement has been greater than in any previous period. Offenders have coöperated with the Bureau, which is backed by adequate laws and public sentiment.

Not only boiler furnaces and locomotives are now complying with the law, but Pittsburgh has smokeless operation of most of its heating furnaces. Besides this the steamboat interests are taking an active part to effect smokeless operation.

Will the wonderful results attained be permanent? Will the methods of the past year continue to be effective so as to enable occasional offenders to permanently comply with the ordinance? The answer rests with those responsible for the smoke. Without legal process or application in any way to the courts, the Bureau has got action that has yielded results only meagerly covered here.

*Chief, Bureau of Smoke Regulation, Pittsburgh.

Fig. 1. Smoky Operation, Crucible Steel Co.

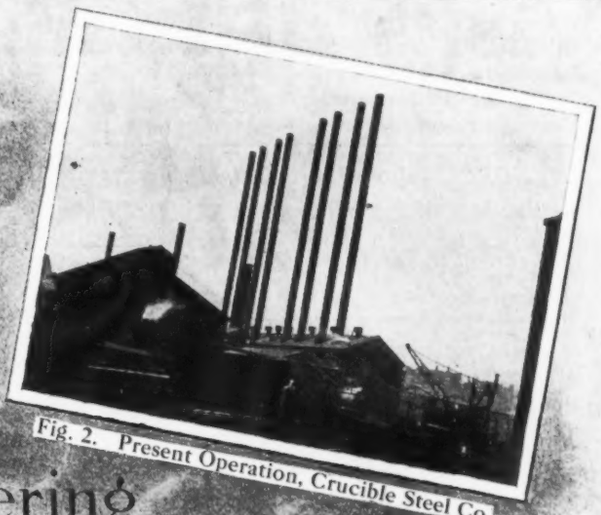


Fig. 2. Present Operation, Crucible Steel Co.

Answering the Smoke Question in Pittsburgh

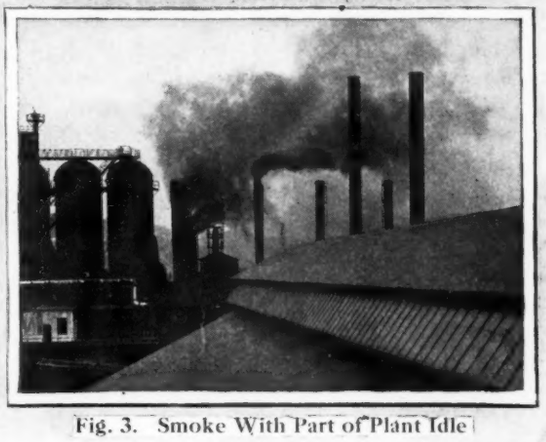


Fig. 3. Smoke With Part of Plant Idle

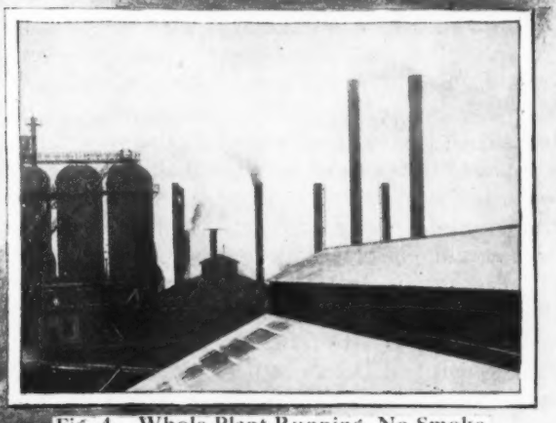


Fig. 4. Whole Plant Running, No Smoke

Fig. 5. Before Air Was Admitted Above Arches

Fig. 6. With Regulated Air Supply Above Arches

Visits of Inspector Brown--II

By J. E. Terman

SYNOPSIS—Brown learns that there is more than one thing to consider when arranging for patching a boiler. The Chief shows him that the boiler maker has to be considered as well as the kind of patch.

Brown experienced many difficulties after making his first mistake in ordering out the two circulating tubes in the Babcock & Wilcox boiler, but he had gained in confidence and in level-headed judgment, and moreover, he did not feel the least embarrassment in asking the Chief or one of the older inspectors for advice on any question that came up.

One afternoon Brown entered the office, having made an inspection of a laundry boiler, and began writing out his report. When the Chief saw him he called him into his office where Brown found the Chief reading a report on a horizontal-tubular boiler Brown had inspected two days before. The shell of this boiler had been so corroded around the blowoff pipe flange that it had been necessary to put a patch on the shell at this point.

"Why did you specify that this patch should be placed on the outside of the shell?" asked the Chief.

Brown was somewhat puzzled at the question, because the explanation was simple and the Chief was not given to asking questions requiring simple answers.

"Well," said Brown, "it was a case of choosing between the lesser of two evils. I knew that the blowoff pipe had to be placed in the patch and that if the patch was placed on the inside of the shell all of the water could not be run out of the boiler through the blowoff connection, which would make it difficult to wash and inspect. I also knew that the patch was weaker, placed on the outside of the shell, but I thought there was less objection to placing it there than on the inside."

The Chief eyed Brown rather closely and asked him if that was as far as his reasoning in regard to this patch

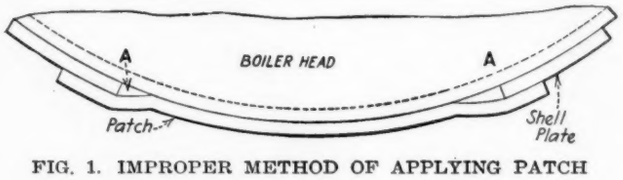


FIG. 1. IMPROPER METHOD OF APPLYING PATCH

extended, and then proceeded to show him that there was much more to the problem than his explanation had indicated.

"In the first place," said the Chief, "your argument for placing the patch on the outside of the shell to allow all of the water to drain out through the blowoff connection is excellent, and if such an arrangement of the patch was practicable your reasoning would be all right, but have you given any consideration as to how the boiler maker is to do the work?"

Brown admitted that he had given the matter but little consideration, as he thought the boiler maker would be fully competent to perform a small job of such character without instructions.

"Well," said the Chief, "your report indicates that the rear sheet of this boiler is so badly corroded that it will be necessary to put on a horseshoe patch extending 28 in. girthwise and 20 in. lengthwise of the boiler and taking in the rear head seam. When you specify that such a patch is to be placed on the outside of the shell, how is the boiler maker going to make the ends of the patch tight where it overlaps the shell plate at each side? Don't you know (drawing a sketch like Fig. 1) that it would be almost impossible to fit the ends of such a patch here (indicating the points *AA*). Even if it was

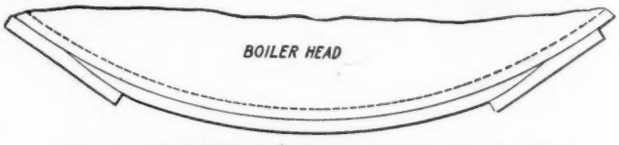


FIG. 2. PROPER METHOD OF APPLYING PATCH

practical to scarf the shell plate at the sides of the patch, the plate forming the patch would have to be considerably distorted in order to properly fit it to the shell. On the other hand, it is an easy matter to heat the corners of the patch in the forge and properly scarf them like this (drawing, Fig. 2).

"With several rivets removed from the head seam on each side of the patch," continued the Chief, "it is a simple matter to force the patch in place and drive the edges of the shell plate down over the scarfed corners of the patch to a good fit. This same reasoning applies to patches on other parts of a boiler shell, where it includes a portion of a girth seam, and it depends on whether a patch is to form a portion of an outside or an inside course of the shell as to whether it will be placed on the inside or on the outside of the course.

"There is another idea," said the Chief, "that I want to correct you on, and that is about the patch being so much stronger if placed on the inside of the shell than if it were located on the outside. You have probably caught this idea from some of the other inspectors, for it seems to be about as contagious among inspectors as measles in a grammar school. If anyone should ask you whether the outside plates of the big gas holder were liable to be blown off on account of the pressure against them, what would you say?"

"Well," answered Brown, "I don't see how a plate could be blown off, even if the rivets were practically without heads, as far as the internal pressure is concerned, for this pressure tends to increase the circumference of the holder, which places a shearing stress on the rivets and there is no tendency to blow off the individual plates of which the holder is composed."

"Exactly so," said the Chief, "and the same thing applies to a patch placed on the shell of a boiler. If a patch is properly fitted and the rivet holes reamed in place and the rivets driven so that they fill the holes, there is no more tendency for such a patch to blow off than there is that the outer lapping plate at a longitudinal seam will be blown off by pulling off the rivet heads. A patch placed on the inner surface of a shell is practically no stronger than one placed on the outside."

Brown returned to his desk after thanking the Chief for his instruction, resolving to spend the next spare time he had in studying some of the other problems in connection with stresses in boiler shells, that he had been considering settled facts, but which he now thought might be open to argument.

What Is Exhaust Steam Worth?

By Everard Brown

This question can be answered in many different ways. So many conditions affect the answer that no broad general statement can be made. The value of exhaust steam may range anywhere from nothing to the equivalent of live steam. Again, perhaps no two persons will view the matter from the same angle. This, probably, is not very important where the live and the exhaust steam are both utilized in the same plant, for the net results to the company would be the same, regardless of the method of calculation adopted.

Often, however, the live steam is used in one department and the exhaust in another, and the heads of these respective departments cannot agree as to what would be an equitable debit and credit, each naturally wishing to show as large a profit as he can for his own domain. The result is, the department supplying the exhaust steam will try to get as large a credit for it as possible, whereas the department using it will try to give as small a credit as possible.

While the solution of the problem may largely belong to the accounting department, it involves some engineering features that are exceedingly interesting. To arrive at an equitable figure for all parties concerned in interplant work, for instance, involves consideration of the type of equipment in use, steam pressures carried, degree of superheat, if any, and various other matters.

If the exhaust steam were used for other purposes than generating power, such as heating, for example, it might be fair to say that the department using it should pay what it would cost to generate the same amount of heat by other means. On the other hand, if the department using the live steam has no use for the exhaust, it might be equally correct to say that the heating is done for nothing except, perhaps, a small expense because of the increased back pressure on the prime movers. The amount could be based upon the increased quantity of steam required by these prime movers, resulting from the greater back pressure.

The price for exhaust steam could also be based upon the assumption that the prime movers might be operated condensing by installing the necessary equipment. Here it might seem fair to charge for such steam the expense of operating the condenser, plus 6 per cent. interest on its initial cost, plus the increase due to the back pressure. By the last method of figuring the department using the exhaust would be made to bear the burden of practically buying and operating a condensing equipment of which the other department would reap a benefit on account of a lower steam consumption due to operating the prime movers condensing. This would not be reasonable. The proper charge would be one equal to the difference in cost between operating condensing and noncondensing, plus the cost due to increased back pressure occasioned by the heating system, but allowing the high-pressure steam department to bear the burden of operating the condenser and the interest on the investment, etc.

However, an assumption of this kind should never be made, because if it is cheaper for the whole plant to operate one department noncondensing and heat the other with the exhaust than it would be to put in a condenser and do the heating by some other means, then it would be foolish to consider the latter condition at all. And if it would not be cheaper, then the condenser should go in, by all means. Furthermore, if an assumption of this kind be made, it would be equally fair for the department getting the exhaust steam to say that the most modern and efficient steam-generating plant should also be assumed and the cost of steam based on using such equipment.

Perhaps a more interesting condition is where the electrical department gets steam, say, from certain mill engines in another department and uses it in a low- or mixed-pressure turbo-generator. The charge might be made equivalent to the cost of steam required for generating independently the same amount of power that the exhaust steam makes possible. This is not just, because if the exhaust were not utilized in the turbo-generator it would be wasted, so that the electrical department can just as fairly say that there should be no charge for it.

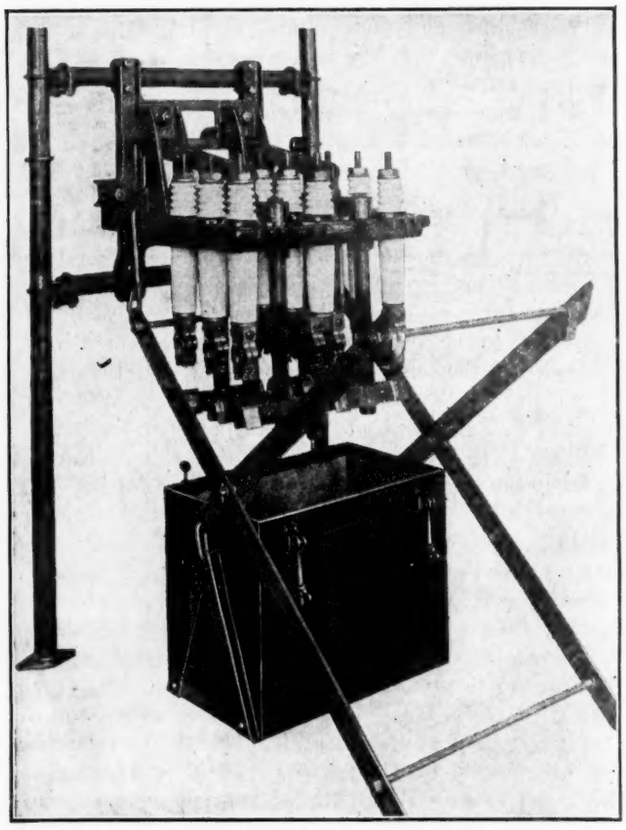
Perhaps the most equitable division of the steam cost would be upon the basis of the amount of energy in the steam under certain assumed conditions and then apportioning the expense accordingly. For example, steam expanded from atmospheric pressure to a 28-in. vacuum will generate as much power as when expanded from 150 lb. pressure to atmospheric. If these conditions obtain, then the cost for steam should be divided equally, except that a certain percentage additional should be charged to the high-pressure unit for condensation. If, however, the steam is superheated, this is not necessary, because there will be practically no condensation. The low-pressure turbine should bear all losses due to condensation, etc., from the exhaust connection of the high-pressure unit and also any back pressure that the latter has to bear.

If the steam pressure is, say 125 lb. and the vacuum 28 in., the high-pressure unit should be charged with more steam in proportion to the ratio between this condition and the theoretical one where the pressure is 150 lb. and the vacuum is 28 in. On the other hand, if the steam pressure is 150 lb., but the vacuum is only 26 or 27 in., the low-pressure unit should bear an additional charge arrived at in the same way. This method would put a premium upon keeping up the equipment and operating it at maximum efficiency and if one end of the installation should fail to keep up to its standard practice, it alone would have to bear the cost incidental thereto. Furthermore the method should not be difficult to maintain because, ordinarily, the average steam pressure does not vary from day to day and the vacuum need not vary either, except perhaps once or twice a year as summer or winter sets in, and then the variation should not be very great unless the conditions are unusual.

Lampblack is the soot or carbon deposit obtained from burning substances such as resin, petroleum, tar, etc., rich in carbon. Little oxygen is allowed to reach the flame, so that it becomes smoky, and the soot is caught upon some cooler surface. For some purposes, lampblack is purified by heating in a closed vessel. It is used by artists in both oil and water colors, and a coarser kind is used by house painters. It is used on carbon paper, is the chief ingredient of india ink and with linseed oil makes printers' ink.

Tank Lifters for Small Oil Switches

Oil-switch tank lifters are a great convenience, particularly in stations where a large number of switches are installed, and while a tank with oil for a comparatively



TANK LIFTER IN OPERATION

small switch is not especially heavy, the character of the load makes it somewhat cumbersome for one man to manage. The result of this is that often the oil-switch contacts are not inspected as regularly as they should be to insure the most satisfactory operation.

The tank-lifting arrangement shown herewith, which is manufactured by the General Electric Co., provides a simple and easy means for quickly lifting an oil-switch tank either up or down the entire distance between the switch frame and the floor. The lifter is made in two widths, one for single- and the other for double-throw switches, and differs only in the lengths of the three rods that join the parallel operating arms. This is necessary because of the difference required in the dimensions of the tanks.

To fasten the tank lifter to the switch frame and lower the tank, two hooks attached to the inner ends of the longer pair of operating arms are placed over the ribs of the switch frame, the operating arms are raised and the tank supports fitted under the tank. Then the wing-nuts that secure the tank to the frame are turned to unfasten the tank, and the arms are lowered to the floor. Finally two catches on the crossrod between the inner set of operating arms are released, and these arms are raised until the tank reaches the floor.

Hopes Pyramid Dumping and Stationary Grates

The main characteristics of the Hopes stationary and dumping grates, designed to burn low-grade anthracite coals, is in the construction of the fire surface. The grates are made by the Hopes Combustion Engineering Corporation, 30 East Forty-second St., New York City.

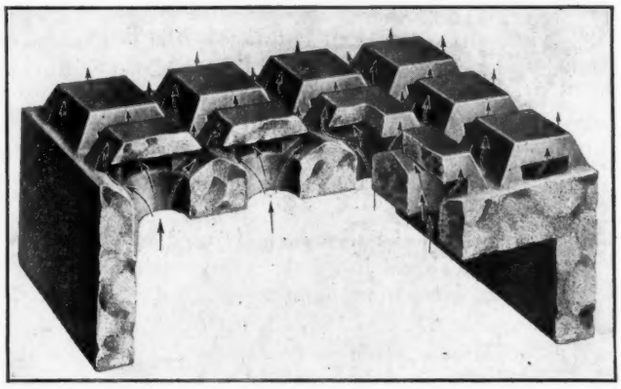


FIG. 1. SURFACE OF HOPES GRATE AND AIR SPACES

Figs. 1 and 2 show that the top surface consists of square pyramidal projections, flat on top, and having an air passage on each of their sides communicating with the central round air hole underneath. Air coming through these holes is split into four currents, comes in contact with the burning gases from four directions, and is delivered almost horizontally, so that the air cannot shoot vertically through the fire bed.

These pyramidal projections are integral with the rest of the bar and are of such dimensions and so located that the air passages open into V-shaped grooves, Fig. 1. This arrangement not only gives the entering air a horizontal flow, but prevents fuel from dropping through the openings into the ashpit. The uniformity of air pressure through the fire surface is further effected by making the top rails on the side bars live members by grooving out the latter, as shown in Fig. 2, and capping

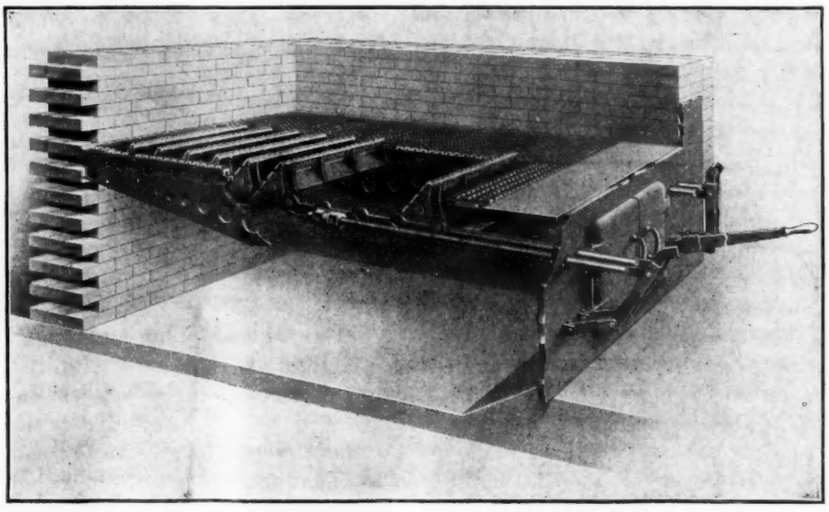


FIG. 2. FOUR-SECTION HOPES DUMPING GRATE

them with a rail of channel iron, the top of which is made with the same kind of a fire surface as the grate bars. This arrangement provides active grate area over every square inch from one furnace wall to the other and from the bridgewall to the dead plate.

The general arrangement of the side bars, connecting-rods and fixtures on the boiler front is shown in the four-section dumping grate, Fig. 2. Both the furnace and back sections can be dumped at one time if desired, by using two levers at once. A view of the top, bottom, side and end of the stationary type of bar is shown in Fig. 3. The stationary grate is made with several sizes

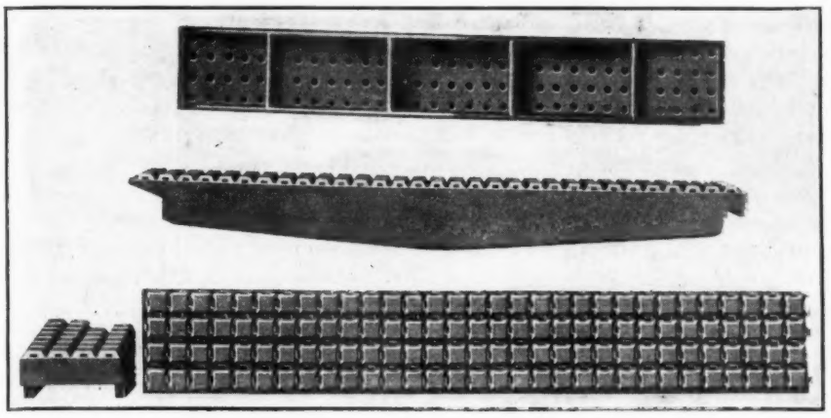


FIG. 3. TOP, BOTTOM, SIDE AND END OF GRATE BAR

of caps and air passages, as is also the dumping grate, for handling various grades of fuel.

Useful Things from Coal Tar

That coal tar is "not as black as it is painted" appears from the following taken from "Gas Logic." Among the things derived from it are the most delicate dyes, perfumes and flavorings, some of the most valuable medicines, the most powerful explosives, oils for lighting, lubricating and burning; photographic developers, benzene, naphtha, gasoline, etc.

When, early last century, it was discovered that illuminating gas could be made by burning coal, the tar residue was almost a waste product. But Frederick Accum suggested that tar be boiled in a still and the volatile products be collected and condensed. The process yielded two oils, one light and volatile, the other heavy. The latter was used as a preservative for wood under water. The former was adopted by a Glasgow chemist named Macintosh as a waterproofing for clothing, and garments so treated still bear his name. It was used also as a solvent in varnish making and, as coal-naphtha, for lighting.

Hofmann extracted benzene from naphtha, and his pupil, Perkin, while trying to produce an artificial quinine, discovered that by treating benzene with nitric acid and powdered cast iron it could be turned into aniline. This worked a revolution in the color industry, almost abolishing the vegetable indigo, from which so many brilliant colors had hitherto been obtained.

Perkin discovered also that anthracene, one of the heavier oils of coal tar, could, by treating it with zinc filings, take the place of the expensive vegetable madder as a dye. Thus, he produced alizarin, one pound of which has the coloring power of 90 lb. of madder. In this way the rich purples, violets, reds, browns, blacks, blues and greens are produced.

Perkin made the perfume known as "New Mown Hay" from another product of tar. He turned the vanillin of the gas works into vanilla flavoring, by treating benzene with an acid he imitated oil of almonds, and by mixing this with vanillin produced heliotrope perfume.

Further steps in the refinement and distillation of coal-tar oils produced carbolic acid, saccharin, antipyrin, phenacetin, aspirin, and many other medicines, antiseptics and preservatives.

In yet another direction some of the coal-tar oils have been turned into such explosives as are now being used in the shells and cannon of the European war.

State and National Control of Water Powers

By Leonard Lundgren*

Water powers in the United States are subject to the dual control of the Federal Government and the several states. The former control arises from the ownership of public lands and the latter from state laws on the appropriation of water. Attempts have been made to show that such dual control is incompatible with the industrial development of the country and actually hinders its growth. In practice, however, the Federal and state governments work in the closest harmony. The regulations of the Secretary of Agriculture, effected Feb. 1, 1915, contain the following:

"Whenever the approval of a state administrative official, board or commission is a condition precedent to the right either to take and use water for power purposes or to engage in the business of the generation, transmission or distribution of power, certified evidence of such approval must be filed before a final permit will be issued. Formal notification by such official, board or commission that the water right has been canceled or that the permission to engage in the power business is withdrawn will be deemed sufficient grounds for the revocation of the permit.

This or a similar requirement has been a regulation of the departments of the Interior and Agriculture for the last five years. During this period no person has secured a permit to construct a water-power plant on public lands without first securing a water right from the state. To facilitate the approval of applications for water power, both by the state and the Federal Government, a coöperative agreement has been entered into between the State Water Commission of California and the Secretary of Agriculture. The agreement provides: First, any application for a water-power site filed with the district forester (an official of the Department of Agriculture) at San Francisco shall have its essential details sent to the State Water Commission; secondly, whenever an application is made to the State Water Commission for a permit to appropriate water from any national forest land, immediate notice shall be given to the district forester at San Francisco; thirdly, no application for a water right involving the use of national forest lands will be approved by the State Water Commission prior to notification that the application has been filed in conformity with the regulations of the Secretary of Agriculture; fourthly, permits for water sites filed with the forester under the provisions of the Civil Code of California will not be issued until the State Water Commission either approves such appropriation or disclaims jurisdiction; fifthly, no preliminary permit will allow construction upon national forest land except in an emergency or to comply with the state law, and then only upon the approval of the State Water Commission; sixthly, where either the district forester or the State Water Commission shall fail to give notification of any action as contemplated in the other parts of the agreement within 60 days of receipt of report of such application, the officer so reporting may take action without waiting further for such notification.

*District engineer, U. S. Forest Service.

The effectiveness of an agreement of this kind is well illustrated by a case recently decided by the Secretary of Agriculture. One of the Western power companies applied for the use of certain water rights, but the application was rejected by the State Water Commission of California, "because they believed the public interests so demanded." The company appealed on the ground that the administration and control of waters of non-navigable streams within national forests for hydro-electric power development rests solely in the Government of the United States, and the State of California cannot, without the consent of Congress, "enact any valid law regulating the appropriation of the waters of national forests for power purposes." The Secretary of Agriculture denied the appeal, as it was believed that better results could be secured under existing conditions by coöperative action between the state and Federal authorities than by any insistence upon strict legal rights on behalf of either.

This incident shows that the United States is not assuming the exercise of any function of the sovereign state. Whatever right of control over water-power sites the Federal Government may have through ownership of public lands, the administration of such sites is being used to supplement the efforts of the state to conserve its natural resources. Still further illustrative of the principle is a coöperative agreement recently entered into between the state engineer of Oregon and the Secretary of Agriculture. This resembles very closely the California agreement.

It is anticipated that other states having laws that permit coöperation will see the advantages that will accrue to all concerned and will accordingly enter into similar agreements. The facts cited in this article are evidence that coöperative control over public lands and public waters can be, and is being exercised in complete harmony by the state and national governments to their mutual advantage and without the surrender of any rights that either may possess.

Writing in the "Vulcan" of March, F. O. Beckett gives an interesting account of how a flywheel burst a few years ago in a works at Sheffield. It appears that the pin holding the valve to the spindle of the boiler stop valve had been replaced by a common $\frac{7}{8}$-in. bolt, instead of a properly fitted pin, and owing to heavy vibration the nut worked off and the bolt fell out. The bolt, of course, soon found its way along the steam pipe and jammed in the double-beat throttle valve. The engine was direct-coupled to a rolling mill, and as soon as the load was taken off the governor became inoperative in consequence of the throttle valve being fouled. As soon as the engineer saw the speed of the engine increasing, he threw off the governor belt and tried to close the throttle by hand; failing in this, he ran to the boiler stop valves, but while closing No. 1 valve the flywheel burst and completely wrecked the engine. One piece of the rim went through the roof and struck the flange of the dome crown of one of the boilers, indented the plate, but fortunately, did no further damage. Another piece cleared the works, crossed the river Don, and buried itself—some say 6 ft. deep—at the door of a cottage from which a funeral procession was emerging, and fortunately, this piece also did not cause personal injury.

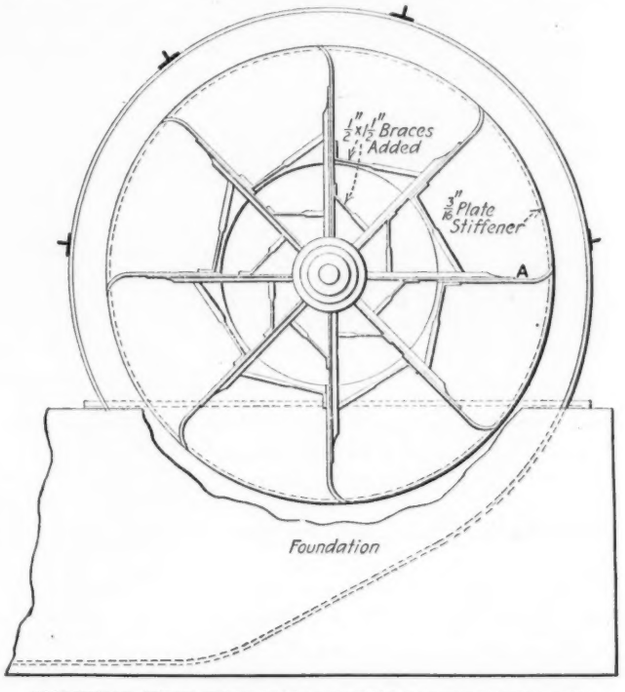
Employment of Minors in Wyoming—A law enacted at the recently adjourned session of the Wyoming legislature forbids employment of children under 14 years of age in operating any steam boiler, steam machinery or various specified kinds of woodworking and metal working machinery, etc. A fine of not less than $25 and not more than $100, or imprisonment for not more than ninety days, or both fine and imprisonment, are prescribed as a penalty for violating the law.

How Breakage of Blower Arms Was Prevented

By John A. Fritz

We have at our suburban plant—American Gas & Electric Co., Scranton, Penn.—two 14-ft. blowers which furnish air to some of our boilers. They are directly driven by center-crank engines. They have an outboard bearing and are fastened to the end of the engine shaft by a rigid coupling, making a three-bearing unit—the outboard bearing and two bearings on the engine.

These blowers are subject to severe service, running as high as 180 r.p.m. They have three spiders on a $5\frac{5}{16}$-in. shaft. The hubs of the spiders are of the usual



SHOWING HOW THE FAN WHEELS WERE BRACED

design, that is, they are cast iron and the arms are wrought-iron tee pieces cast in an extended arm on the hub. We experienced considerable trouble with these arms breaking off where they enter the cast-iron hub. The plate vanes also break at the ends of the arms at the point *A* (see illustration). We attribute it to the lack of weight in the moving parts to carry the engine over the center, there being no flywheels on these units. The periodical indicating of the engine fails to show any defects in the valve setting.

After having a number of these arms break and completely wreck the blower and having to patch up several arms on the new spider shortly after putting them in service, we came to the conclusion that we would brace the arms, as shown in the sketch. This was done about eight months ago, and an improvement was immediately noticed in the operation of the blower. It ran much quieter and with less vibration, and where we formerly had considerable trouble with the bearings and crosshead of the engine, no trouble is now experienced and the unit runs smoothly—*A. G. E. Bulletin.*

Propeller Fans deliver air through a short direct duct directly proportional to the speed and require power as the cube of the volume or velocity.

Editorials

Learning Engineering Lessons from the War

Reading war news can become a sort of mental dissipation, for it is hard to resist the intensely interesting daily paper. No engineer with red blood in his veins can be blamed for taking a live interest in the great tragedy unrolling in Europe, deplorable as it is, but there is a difference between insatiably wading through columns of conjecture and slaughter and attempting to learn something of technical value from it all. The greater part of the scientific material has been concealed for military reasons, but enough has been, and is being, published to give the engineer plenty of food for thought. Certainly, some study of these things is justified on the triple ground of cultivating broadmindedness, of being interested as a good citizen in preparedness and of noting how much depends upon the fidelity and ability of engineers in war as well as in peace.

The naval aspects of the war are apt to be of greater interest to an operating man than the land actions. The latter have been literally revolutionized by the development of the aëroplane, which is the eye of the modern army corps, and the spectacular feats of daring aviators command the admiration of everyone. Some day will be told how the motive power of these appliances behaved under stress, the ingenious makeshifts compelled in emergencies, the weak points in lubrication and in structural strength of shafts and bearings, propellers and chains, and the effect of forced speed on the wear of materials. On the sea, however, the war is being conducted with equipment far more familiar to the engineer, and for this reason the study of marine power is of unusual interest at this time, wholly apart from the question of investigating arms, armament and explosives. These last can very well be left to the naval-engineering specialist, but the study of motive power in all its bearings as applied to both the navy and merchant marine is particularly appropriate now. Many of the vessels were built long enough before the war to receive a good deal of publicity, and while the improvements foreign navies are making as the result of their experiences to date are hooded, the study of all that is known about the propulsive equipment of vessels is a good preparation for better understanding the lessons from their operation.

An engineer who thus tries to inform himself on motive-power questions, reading that which bears on the influence of speed on naval successes, studying methods of coaling at sea, looking into the design of oil engines for submarine service, and noting the arrangements of boilers, pumps, turbines, etc., on war ships, particularly as mentioned in occasional discussions of authoritative writers, combining such interests with a little personal investigation of equipment policies in our own navy, will broaden himself materially and certainly get more out of the war news than one who reads merely out of curiosity. He will follow everything that describes the installation of turbo-electric driving on our forthcoming battleship "California," and various details of that important pioneer equipment are almost sure to be widely printed.

The acceptance by Edison of the opportunity to render valuable service to the navy as technical adviser in inventive development is gratifying to civilian engineers the country over, and while much of this work is likely to be confidential, the results will come out in due course and will doubtless contain lessons applicable to peaceful as well as to warlike machinery. While engineering information comes slowly, it is well worth studying when it does come, and the engineer who acquaints himself with this side of the conflict prepares himself to better appreciate the different conditions of his own daily service, contrasted as it is with that under the limitations of military direction on land and sea. Let certain phases of war news become an engineering hobby, and one will be surprised to find how quickly his outlook and professional interest are broadened, in comparison with the mental diffusion accompanying haphazard reading in these historic days.

Exhaust Steam Versus Live Steam for Heating

For some time engineers have differed regarding the relative value of exhaust and live steam for heating. This problem could be easily solved experimentally in many installations, and some information along this line has already been published. But nevertheless, it is surprising that more such data and results have not been submitted.

It is quite easy to analyze the matter from a purely theoretical viewpoint by referring to a steam table or Mollier heat diagram. From it one can determine that live steam at any given boiler pressure and quality or superheat contains a certain number of heat units. Suppose this pressure were reduced for heating by a suitable reducing valve to five pounds. The steam, radiation neglected, would retain the same number of heat units, though it would become superheated during this change. Hence the heat available for heating with live steam may be assumed to be equal to the initial heat of the steam.

Supposing again that the high-pressure steam were passed through an engine. Obviously the steam exhausted into the heating system contains less heat than that entering the engine by an amount equivalent to the developed mechanical energy plus certain radiation losses in the engine. One would conclude, on purely theoretical grounds, then, that the reduced live steam, containing more heat units per pound than the exhaust steam, would prove better for heating.

A prominent operating engineer, however, recently stated his belief from several tests, that exhaust steam was better and more efficient for heating than live steam. His company had a central-station connection, for emergency purposes, in one large office building which had its own power plant. He decided to carry out some tests to satisfy himself regarding the costs of central-station power and live-steam heating as compared with his present local

costs. Records were made covering several days' operation, using the exhaust steam from the engines in the heating system. Then on Saturday night the central-station current was switched on and the engines shut down. Reduced live steam was used for heating until the following Monday morning. The outside temperature conditions and winds were practically the same throughout the tests, yet difficulty was experienced keeping some rooms warm enough with the live steam. These trials showed that more coal was burned when the engines were shut down than when they were operating and generating power. This result is so surprising that one is led to speculate on the influences that produced it.

Superheated steam, being more of the nature of a perfect gas, radiates its heat less readily than wet steam. This might account for insufficient heat in certain rooms. The greater volume of the superheated steam might also be a determining factor.

Another suggestion has been made that the pulsation set up in the heating system by the exhaust of an engine prevents the formation of dead-air pockets and air bubbles on radiating surfaces. This would increase the efficiency of the heating system. But where a steam turbine with throttling governor exhausts into a heating system, such pulsations would not exist.

If there is any special virtue in exhaust steam for heating, it should be known definitely, for it would have an important bearing on the question of central-station power versus individual generating plants. Obviously if it costs more to heat with reduced live steam than with exhaust steam, this factor should enter in when considering the substitution of central-station power for the individual power plant.

Doubtless considerable data bearing on this subject are already on file in various offices, and such would be welcomed for publication to throw further light on this puzzling question. Moreover, this is an attractive field for experimental work in certain favorable installations, and it is to be hoped that some extensive research work may be undertaken in the near future that will reveal the unknown factors involved in the two methods of heating.

Some Day, Perhaps

Lawful compensation and the sympathetic expressions of friends cannot drive away the profound sorrow of the widow or give back the father's caresses to the children of Walter Hipple, of Toledo, Ohio. Like the veritable army that has gone before him, Hipple was a victim of negligence so common that many of those guilty would be astounded to be accused.

Here, a man in the early thirties is scalded to death in a boiler because his fellow engineer, not knowing he was there, opened the blowoff valve on the boiler alongside, allowing steam and water to back through the open blowoff of the idle boiler. After all, the result of the accident is not so uncommon as to wring from many much more than a heavy sigh.

Some day, perhaps, when Negligence and Death will have long stalked arm and arm, and the sobbing of bereaved widows and the wailing of children, and the fear that each may be the next victim of these grim companions—some day, perhaps, men will learn that reasonable care can divorce the two and that sufferable injuries at most are preferable to funeral processions.

Safety First in the Plant

More men are killed in power plants, where there is comparatively little danger, than in factories, where the workers must be more cautious because of the greater danger. At least the number of fatalities is proportionately greater in the power field than in other industrial lines, because there are not so many men employed there. Authority for the foregoing statement is a man who makes his living by advocating safety-first devices.

It is not to be wondered that what he said is true for the same reason that a larger percentage of swimmers drown than nonswimmers. Swimmers grow careless; they feel that there is no danger because of the fact that they can swim. Nonswimmers are always on guard, for they are continually aware of the danger of drowning.

Many other examples could be cited where it appears to be safer to be in considerable danger than little danger, since statistics bear out this point. From this it is to be concluded that the Safety First movement is not so much dependent upon safety devices for its success as upon the proper teaching of safety methods. We need not be constantly in dread of danger; we should be unafraid of danger. But if we keep our wits about us at all times and think before we act, there will be less danger and fewer people will get hurt.

Thinking is analogous to theory; acting is analogous to practice. Theory and practice must go hand in hand for the furtherance of perfect safety.

The House We Live In

Do we ever think of the source of heat in the human body and of its control and why we don't take on the temperature of the air that surrounds us, whether it be in the Arctics or in the fire-room of a ship at perhaps 125 degrees?

We eat food. The blood carries carbon, the air the oxygen. The lungs bring them together where they burn, but bring them together so smoothly and in so marvelous a way that combustion takes place at a temperature that is not destructive—the temperature of the human body. This is one of the reasons why we are the most efficient machines on earth.

When we run we exert ourselves. We breath hard, our pulse quickens, more fuel, heat and energy are needed, and vice versa when we sleep.

So delicate is this body that a temperature of 105 is sometimes fatal, but again nature is on guard and provides perspiration which allows us to live in surroundings of much higher temperature.

If we are cold we walk fast to keep warm—once again more fuel, heat and energy.

But should we abuse ourselves—allow fever perhaps to attack us—then something goes wrong in the lungs; up goes the temperature and the plant goes out of business.

Truly, this "house" we live in is a wonderful thing, and we should do our share to foster it.

The index to volume 41 (the first six months of 1915) will be ready in a few days. Anyone who has not been receiving the indexes regularly and wishes them can have his name put on the index mailing list by sending a postcard request to that effect.

Correspondence

Blowing Out Steam Lines

The interesting note in the issue of June 29 on E. E. Strong's suggestion that new steam lines should be clear of iron filings, dirt, etc., before they are put in use, recalls a recent case where a customer thought of rejecting a big lot of our hydraulic valves because "they stuck." Our representative immediately called and on taking the valve apart found from the character of the scoring that it was clearly evident that sand or dirt had caused the trouble. New pipe lines and a new pump had just been installed.

Not infrequently we find this trouble in steam and hydraulic lines, and the publicity you have given this matter ought to save thousands of dollars to users of valves, traps, etc.

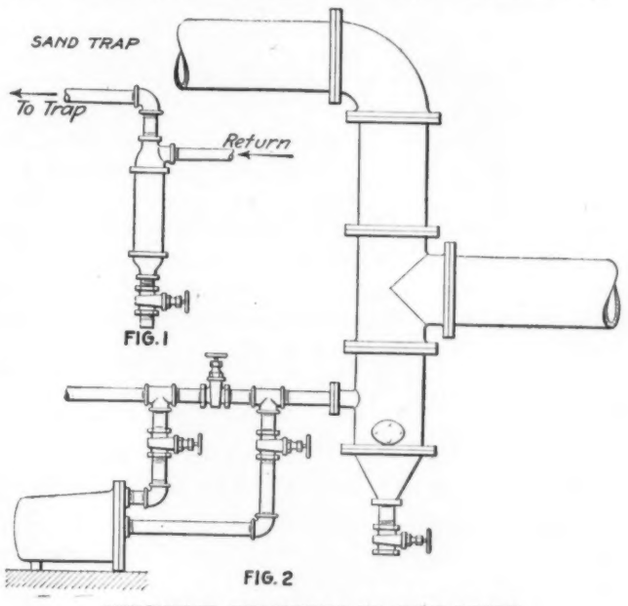
B. G. WARING,
President, Yarnall-Waring Co.

Philadelphia, Penn.

The importance of clearing steam lines before putting them into use, as pointed out in a recent editorial in *Power,* cannot be too strongly emphasized. Only those who have had the experience and responsibility can realize the trouble and anxiety that such neglect will cause. To have a trap fail and allow an important steam main to fill with water and start a terrific water hammer is serious beyond question. I have seen a six-inch extra heavy stop valve burst in this way. Certainly no engineer alive to his responsibilities will permit a steam line to be put into service without using all possible means to clear it of foreign matter. A small piece of dirt in the pilot valve of a reducing valve will put it out of action. Valuable material under heat treatment may be ruined from the failure of such a regulator. Traps have been thrown out, not because they were failures in themselves, but because they were not kept free from dirt, which obstructed the passages through them.

Where gate valves are used in steam mains of the larger sizes an accumulation of dirt will interfere with their being closed, especially when the valve is in a horizontal position (which, by the way, they should not be given if possible to avoid it). When the valve is in this position the dirt falls into the lower guide and causes the gate to roll on its edge slightly and lock itself fast. We have had considerable trouble from this cause. If the valve is set vertically the dirt will fall to the bottom and just before the valve closes the high-velocity steam under the edge of the disks will clear the way. Screens in front of a regulator, while desirable, are not always a preventive, as some of the finer particles get through the wire and we have at times found screens broken; perhaps from a rush of water, and perhaps corrosion, even though made of brass. For piping delicate apparatus such as hospital sterilizers, brass pipe is often used to avoid the foregoing difficulty as far as possible.

Steam fitters are often indifferent, and we have taken out of large steam mains pieces of wood from plank to sawdust, overalls, waste, rags, wrenches, bolts, nuts, mud and sand. All such stuff is easily removed if you are on the spot to see that it is done, but the greatest trouble is from sand and mill scale. Sand is frequently used as a filler for pipe to prevent it flattening or buckling during the process of bending, and when heated some of this sand fastens itself to the inside of the pipe. The most persistent pounding, scraping and brushing will not dislodge it, but some will be loosened by the breathing action of the pipe and what this vitreous matter will do



SEDIMENT CHAMBERS IN PIPE LINES

to the working parts of the cylinder is "a plenty." Pipe bent by this process should be avoided.

Sand and scale seems to be the greatest source of trouble in traps. The best way to deal with this is to insert a sand trap in the return to catch the dirt. A trap of this kind can be easily made and blown out, as shown in Fig. 1.

Conditions generally make blowing out large steam mains impracticable. Some are of great length and may have numerous bends and risers through which it would be impossible to drive the dirt. Besides, the volume of steam and water liberated inside buildings, to say nothing of the noise, would prevent it. I tried it once on a new 12-in. main about 80 ft. long, where the conditions seemed favorable. We got out a lot of dirt and came near getting out the police reserves. On account of the deafening roar and the volume of steam escaping from the building, it was thought that an explosion of some sort had occurred.

When repairing engines we are extremely careful not to leave dirt or grit on any of the working surfaces. Why not exercise the same care to prevent leaving dirt in steam mains? Most contracts have clauses specifying that the new lines shall be blown out, but the contractors know that they are seldom required to do so. Why not

change the clause and require the contractor to erect clean pipes? When the joints are of the Van Stone pattern it should be specified that loose scale formed when flanging should be removed—the sand blast will be found effective in this operation. If the cast fittings have not been thoroughly cleaned they should be treated in the same way. All screwed pipe should be chamfered on the inside edge, and just before it is erected should be brushed out, blown out with a steam blast or washed with a hose. Screwed couplings should be removed and cleaned, and when made up again the lead or other dope should be put on the male thread only.

No matter how much care is taken, some dirt may find its way into the traps if the connection to the trap is taken from the bottom of the water leg. Some distance above, as in Fig. 2, is much the better way.

WILLIAM HIRST.

Trenton, N. J.

Unusual Piston Failure

J. W. Dickson asked to hear from readers who have had accidents similar to that which he described in the May 18 issue, page 689. A hoisting engine of which I was in charge had the bull ring held in place by stud bolts tapped through the piston web and secured by jam nuts, six being used to hold the piston central. One stud worked out and vibrating between the piston and follower plate wore through the latter. The hole was filled with a hard babbitt, and the piston is still in use.

F. RICHARDS.

Iron River, Mich.

Finding an Elusive Ground

It was a two-wire, 110-volt system and there had been a ground on it for some time. The electrician spent much time looking in vain for a bare wire, and the ground continued to come and go. Then it was found that there were two grounds. Sometimes there was one on the positive,

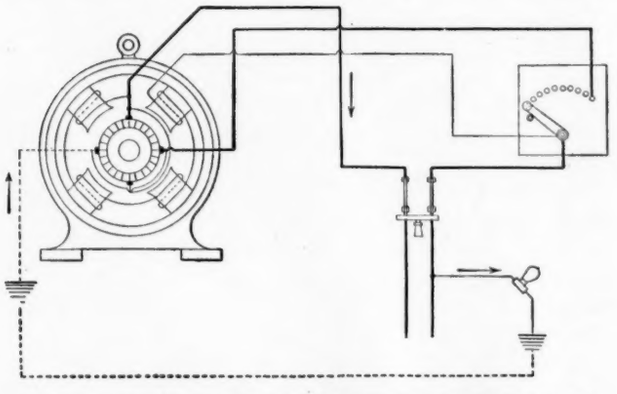


FIG. 1. GROUND INDICATION WITH RHEOSTAT IN STARTING POSITION

at others one on the negative, but luckily they did not come together. Finally, in the midst of a test the lamp slowly faded and went out. It was then shifted to the other wire, and there showed a strong ground.

Here was something which looked like a clew. Though the trouble appeared to be first on one side and then on the other, it now looked as though the fault was in one spot and conditions made it appear to change. The clew led to a distant part of the yard to a motor, which was in use intermittently. A diagram of the motor wiring was made and a point found which could, if grounded, produce such results. The two conditions are shown in Figs. 1 and 2, the dotted line in each case indicating the path of the current to the ground.

Investigation proved the diagnosis to be correct. It was found that the men had been in the habit of leaving the

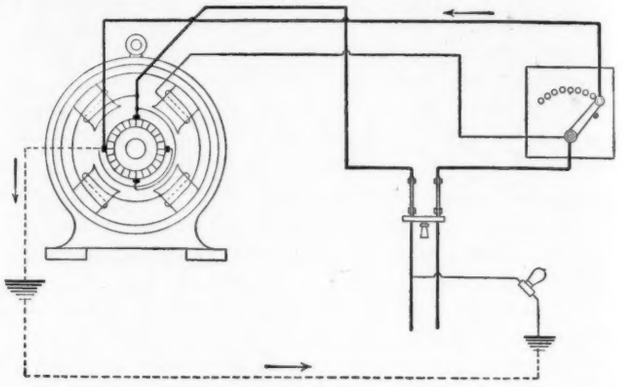


FIG. 2. GROUND APPARENTLY ON OTHER SIDE WITH RHEOSTAT IN RUNNING POSITION

switch in when the motor was not in operation. In that case the field was on and so was the ground. But as soon as the rheostat handle was moved in starting the motor, the path of least resistance began to change and the ground flopped over to the other side

WILLIAM E. DIXON.

Cambridge, Mass.

Vacation for Engineers*

No, I'm not dreaming—I really spent two weeks in Minnesota and surely caught a lot of black bass and pike. And that is not all—I got rid of that run-down, tired-out feeling and am really glad to get back in harness again. I have had such vacations for several years and certainly appreciate them. Desiring to help others enjoy the same rest and recreation, I will tell how I secured this luxury.

My predecessor kept everything he knew about the place to himself, held what assistants he had in just as narrow a path as he could and did not get any vacation, because the plant would have been tied up in about two days after he was gone. He finally resigned (by request) and I was hired to take his place at the salary he had received.

After getting familiar with the plant, I made a young fellow my understudy and instructed him thoroughly so that in less than two months I could leave the plant if necessary and feel that things were all right.

The first time I asked the manager for a day off to go hunting, he seemed much surprised and said he was afraid things would blow up and there was not any one he could put in my place. I told him I had taught one of the boys and he need not worry, so he let me go, but he made about a dozen trips to the engine room while I was gone. Nothing happened, and a month or so later I was off a couple of days on account of the arrival of my first son, and everything went just as smoothly as possible.

*Comment on the foreword in the July 13 issue.

After being with this company a year, I received an offer from another at a larger salary. I told the manager about it, and also informed him he need not worry about my leaving, as things would run without any trouble until a new man was familiar with them. He was not used to this kind of talk and promptly gave me a raise larger than I expected and also sent me up to Minnesota for a two-weeks' fishing trip.

I appreciated this and redoubled my efforts to please him. Ever since, I have had raises and vacations quite regularly. I think the engineer is largely responsible for not receiving a vacation; he is afraid to have an understudy because he might lose his job to him. The firm that is mean enough to place an understudy in your position at a smaller salary or because you want a little time off once in a while is not worth working for, and the sooner you get away from it the better for you.

I have never known an engineer that had an understudy to lose his position for this reason, either directly or indirectly, and I have seen several get vacations and advances in salaries.

Get your plant in such shape that you are not missed when you are gone, and a vacation will be easy. Make your employer give you what you deserve or get a position with one that will appreciate you.

H. G. SCHULER.

Kansas City, Mo.

Two-Pressure Hydraulic Service*

Mr. Hirst's comments upon my brief description of the two-pressure hydraulic plant were noted with interest. It appears that the description lacked something in clearness. The plant operates in a satisfactory manner and the two accumulators float so steadily that no motion was noticeable in a time-exposure photograph, of the 700-lb. accumulator.

As was shown in the diagram the pump delivers direct to the 1200-lb. pressure accumulator. When this accumulator nears the top of its stroke it opens a valve and permits the surplus water, over and above that required for the 1200-lb. mill line, to flow to the 700-lb. accumulator. The 1200-lb. accumulator will not shut the pump down until the 700-lb. accumulator has also reached the top of its stroke and opened the relief valve. When the pump has stopped the 1200-lb. accumulator will drop a sufficient amount to close the valve to the 700-lb. accumulator, which in turn will drop until the relief valve closes. Any further fall of either of the accumulators will then start the pump.

A pump governor which regulates the delivery of the pump to conform to the service demands upon the system is such an obvious element of any installation of this kind that its mention was not considered necessary. The only surplus water that will reach the pump through the relief valve is that small quantity required to permit the accumulators to fall to the point where the valves close. Almost any good hydraulic valve suitable for 1200 lb. pressure can be used. The device for operating this from the accumulator, however, must be arranged to permit some accumulator stroke between the opening and closing stops on the rod.

*May 18, June 6, 1915.

In describing the pumps I omitted to mention that the 13&26x4½x24-in. outside-packed plunger pump has a duplex water end as well as a cross-compound steam end and that the cranks were set quartering. It would not be difficult to so arrange such a pump that it could be started by admitting live steam to the low-pressure cylinder, if necessary.

In commenting upon the ratio between the steam and water ends of the pumps (duplex 12&18x5¾x16-in.) Mr. Hirst remarks that it is a matter of steam pressure and assumes 150-lb. gage. The pumps are operated with 175-lb. gage pressure with some superheat, and the flywheel pump exhausts into a condenser, and there is a larger margin between the steam and water ends than assumed by Mr. Hirst.

If Mr. Hirst will refer to the section on hydraulics in most works upon physics, he will find a diagram, with an explanation which may assist him in understanding how a line supplied from one source may have 1200 lb. pressure at one point and 700 lb. pressure at another, and this without any valve between the two sections.

A. D. WILLIAMS.

Cleveland, Ohio.

A "Safety First" Stick

There are places that are hard to reach while the machinery is in motion, and a slip while trying to clean these places might cause injury or death by coming into

SLOTTED HOLDER FOR WASTE

contact with the moving machine. To facilitate cleaning without risk of injury, I use an ordinary lath with a slot in the end, as shown.

In using, a piece of waste is slipped into the slot and then turned a time or two, forming the waste into a ball. It is surprising the number of difficult places that can be reached with perfect safety.

EARL PAGETT.

Coffeyville, Kan.

Materials to Aid Combustion

Warren D. Lewis is to be complimented for the interesting and capable criticism on page 61 of *Power*, July 13, of the undersigned's suggestions in the matter of aids to combustion. While he apparently takes issue with my statement, I will accept his arguments as correct in general for the conditions that he apparently has in mind.

There is, however, a difference in the line of arguments and one that is frequently made in similar cases. Mr. Lewis refers more to the constructions, whereas I referred more to the principles. If the principles do not exist or if it is impossible to make use of them in any practical way, then my suggestions fall bravely to the ground. I left it to the readers to work a use for the principles and did not have any particular arrangement for the bars to be placed in. The examples given in my suggestions are left purposely indefinite so that the applications of the principles may be worked out by the practical man.

In the matter of these bars for aiding combustion, there was nothing to prohibit the reader from using material other than iron, or for removing them after they did their work if it was too hot for them, or for placing them so they would not interfere with the leveler, and in every case arranging them so they would not interfere with the proper operation of the furnaces.

A. P. Connor.

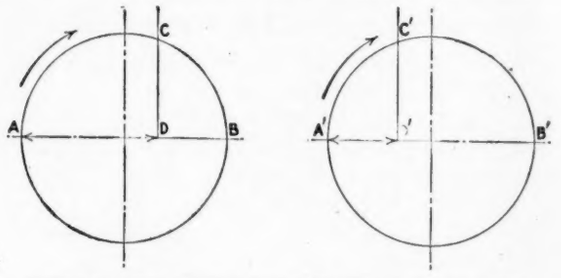
Washington, D. C.

Setting Double-Eccentric Corliss Valves

Steam seal in Corliss valves is the amount the steam valve overlaps the edge of the port when the dashpot is at its lowest position, and this should not be confused with lap. Lap is the amount the edge of the steam or exhaust valve lacks of being line in line with the edge of the port when the wristplate is in its central position with the steam valves hooked up. In both double- and single-eccentric engines the seal is always positive; that is, when the dashpot is home the steam valve must be closed by an amount sufficient to prevent an abnormal leakage of steam.

In the single-eccentric type the steam lap is always positive and varies with the size of cylinder. But in the double-eccentric type the steam lap is always negative; that is, the steam valves are open by the amount of the negative lap when the wristplate is in its central position with the valves hooked up, and this varies with the size of cylinder.

If one has a table showing the amount of negative lap of the steam valves for different sizes of cylinders, the method for setting valves is practically the same for



SINGLE AND DOUBLE ECCENTRIC DIAGRAMS

double- as for the single-wristplate type. But no such table has ever been published to my knowledge, and indeed, the engineer is independent of such a table if he proceeds with the adjustment in the following manner:

First, with the dashpots in the lowest position, adjust the length of the dashpot rods until the steam valves are closed sufficiently to prevent an abnormal leakage of steam when the steam chest is filled with steam at boiler pressure. This can be determined to one's own satisfaction by admitting steam to the steam chest and noting the leakage by means of the indicator cocks. Having the dashpot rods adjusted, adjust the steam links until the hook comes over sufficiently to pick up the steam valve when the wristplate is at its maximum travel.

If it is desired to determine the negative steam lap for this setting, hook up the steam valves and set the wristplate in its central position and note how much the valves stand open.

To determine the maximum range of cutoff for a given setting of the valves, draw a circle with a diameter equal to the horizontal throw of the wristplate, as at AB and $A'B'$, and call this the eccentric circle. Throw the wristplate to its extreme position in either direction and then throw it slowly in the opposite direction and note how much of its travel the wristplate has passed over when the steam valve has come to its lead position, as at D and D', and at this point erect a perpendicular intersecting the eccentric circle at C and C'. If the knock-off cam comes into action and trips the steam valve it must do so while the eccentric is traveling from C to B or from C' to B'. The arcs AC and $A'C'$ include the angle of seal and the angle of lead; so, if seal or lead, or both, is decreased, the range of cutoff is increased by the same angle. And this readjustment would probably be advisable in case the maximum load on the engine should outgrow the original setting of the valves.

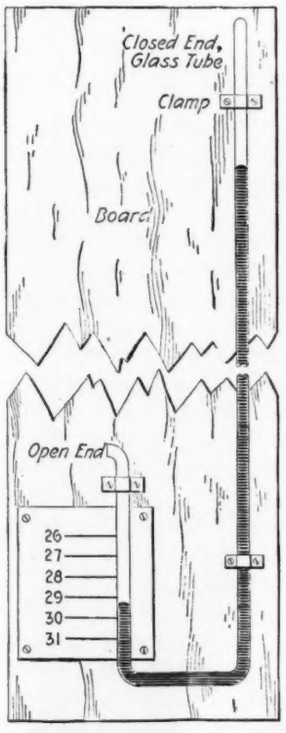
In the double-eccentric type of engine, the knock-off cam must come into action before the eccentric gets to its extreme travel; otherwise, the valve would remain hooked up, and before it closed positively, the exhaust valve on the same end would open and allow steam to blow through the engine.

R. L. Shipman.

New York City.

Direct-Reading Barometer

The illustration shows what may be called a direct-reading barometer. It is exceedingly simple and easy to make and is sufficiently accurate for use around the ordinary power plant. The glass U-tube is familiar to all, but the scale and adjustment are, I believe, new. The scale is laid off with the prime marks each half an inch apart and marked as inches, in the manner shown. The scale is then adjusted with respect to the tube, so that the reading at the lower mercury level is the same as the measured distance vertically between the mercury surfaces, and then fastened. When so made and set the scale will read directly at any barometric height.



BAROMETER COMPLETE

Care should be taken not to put a strain on the U-tube and to allow for its free expansion and contraction, therefore soft leather is preferable to metallic clips for fastening it to the board or backing.

The scale as shown must not be confused with inches of vacuum familiar to the engineer, notwithstanding that the reduced air pressure at the open end is equivalent to a partial vacuum. The scale reading for a vacuum gage would be the reverse with zero inches vacuum, at about 30 and increase upward. The tube in that case would have to be extended to 30 or more inches in height to measure a perfect vacuum.

Manchester, N. H. Miles Sampson.

Inquiries of General Interest

Compression—What is meant by compression?

A. H.

The term compression, when applied to an engine or the steam end of a pump, refers to the action of the piston, during its return stroke, in compressing any exhaust steam which may be left in the cylinder or clearance spaces at the time the exhaust valve or passages are closed.

Height Necessary for Condensing Pipe of Steam Loop—In a steam loop, how high should the horizontal, or condensing, pipe be above the level of the boiler?

H. N. W.

The elevation of the condensing pipe must be such that the pressure delivered from the condensing pipe to the top of the drop leg, plus the hydrostatic pressure due to water in the drop leg above the level of the water in the boiler, will exceed the steam pressure on the boiler by enough pressure to overcome pipe friction and pressure required for raising the return check valve.

Weight Raised by Screw Jack—Neglecting friction, what weight can be raised vertically by a screw jack, if the screw has four threads to the inch, and a force of 50 lb. is applied to the end of a turning bar which extends 3 ft. from the axis of the screw?

H. C. M.

In one complete revolution of the point of application of the force around the axis of the screw, the force would move through $3 \times 2 \times 3.1416 = 18.8496$ ft., or 226.1952 in., and would develop $226.1952 \times 50 = 11{,}309.76$ inch-pounds of work; and as one revolution of the screw would raise the screw ¼ in., the weight raised would be $11{,}309.76 \div \frac{1}{4} = 45{,}239.04$ lb.

Velocity of Water in Pump Discharge Pipe—What would be the velocity of flow through the 3-in. discharge pipe of a pump which delivers 100 gal. of water per minute?

W. H.

The volume of water flowing would be $100 \times 231 = 23{,}100$ cu.in. per min., and as the cross-sectional area of the stream would be $3 \times 3 \times 0.7854 = 7.0686$ sq.in., the velocity of flow past a given point would be

$$\frac{23{,}100}{7.0686 \times 12} = 272.33 \text{ ft. per min., or}$$

$$\frac{272.33}{60} = \text{about } 4.54 \text{ ft. per sec.}$$

Tracing Cause of Engine Back-Pressure—How can it be determined whether excessive back-pressure, shown by diagrams taken from an engine, is the fault of the engine or due to back-pressure of exhaust pipes?

P. S. B.

The best method is to take diagrams with the indicator attached to the exhaust pipe, employing the same indicator and indicator spring as used for indicating the engine. If the back-pressure results from the piping, the diagrams taken from the exhaust pipe will show substantially the same amount of back-pressure as those taken from the engine, but if materially less, then the trouble is due to contracted exhaust passages or failure to secure full opening of the engine exhaust valve.

Punched vs. Drilled Holes for Riveted Joints—What is the relative strength of boiler joints having the rivet holes punched or drilled?

J. R. P.

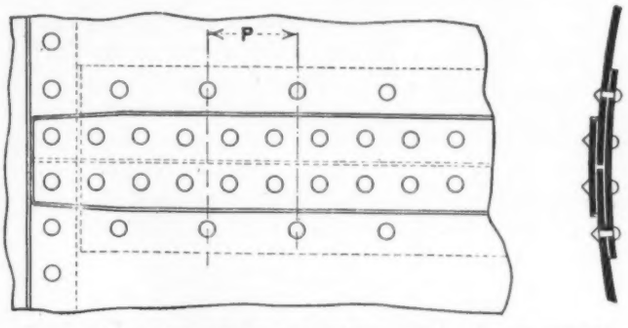
Reliable experiments have shown that whether the holes are punched or drilled the boiler plates invariably lose part of their tensile strength in the section of solid material left between the rivets of a seam. The reduction of strength, and the difference due to punching or riveting, is less in soft material, but in ordinary boiler steel, especially the harder grades as generally handled, the loss of tensile strength from punching is about 12 per cent., whereas when holes are drilled, or punched holes have ⅛ in. of metal reamed off to remove the material that is injured by the punching process, the reduction of strength is not more than 1 to 2 per cent.

Efficiency of Butt-and-Double-Strap Joint, Double Riveted—What would be the efficiency of a butt-and-double-strap joint, double riveted, with tensile strength of the plate 60,000 lb. per sq.in.; thickness of the plate, $\frac{7}{16}$, or 0.4375 in.; thickness of the butt straps ⅜, or 0.375 in.; pitch of the rivets of the row having the greatest pitch, 5.5 in.; diameter of the rivets after driving, $\frac{15}{16}$, or 0.9375 in. (cross-section 0.69029 sq.in); strength of rivets in single shear 42,000 lb. per sq.in. of cross-section, and in double shear 78,000 lb. per sq.in. of cross-section; and the crushing strength of the plates, 95,000 lb. per sq.in. of cross-sectional area?

C. E. P.

The figure shows an elevation and sectional view of a portion of a butt-and-double strap joint, double riveted, in which the dimension P illustrates the unit of pitch which is generally considered, namely, the pitch of the rivets of the row having the greatest pitch.

The efficiency would be the strength of the joint for a unit of length divided by the strength of the solid plate for a unit



BUTT-AND-DOUBLE-STRAP JOINT, DOUBLE RIVETED

of length. The pitch being 5.5 in., then for a unit of length of joint,

(A) the strength of the solid plate would be,

$$(5.5 \times 0.4375) \times 60{,}000 = 144{,}375 \text{ lb.}$$

The strength of the joint, depending on (B) the strength of the plate between the rivet holes in the outer row would be

$$(5.5 - 0.9375) \times 0.4375 \times 60{,}000 = 119{,}765 \text{ lb.;}$$

depending on (C) the shearing strength of two rivets in double shear, plus the shearing strength of one rivet in single shear would be,

$$(2 \times 78{,}000 \times 0.69089) + (1 \times 42{,}000 \times 0.69029) = 136{,}677 \text{ lb.;}$$

depending on (D) the strength of the plate between the rivet holes in the second row, plus the shearing strength of one rivet in single shear in the outer row, would be

$$[[5.5 - (2 \times 0.9375)] \times 0.4375 \times 60{,}000] + (1 \times 42{,}000 \times 0.69029) = 124{,}148 \text{ lb.;}$$

depending on (E) the strength of the plate between the rivet holes in the second row, plus the crushing strength of the butt strap in front of one rivet in the outer row would be

$$[[5.5 - (2 \times 0.9375)] \times 0.4375 \times 60{,}000] + (1 \times 0.9375 \times 0.375 \times 95{,}000) = 128{,}554 \text{ lb.;}$$

depending on (F) the crushing strength of the plate in front of two rivets, plus the crushing strength of the butt strap in front of one rivet, would be

$$(2 \times 0.9375 \times 0.4375 \times 95{,}000) + (1 \times 0.9375 \times 0.375 \times 95{,}000) = 111{,}328 \text{ lb.;}$$

and depending on (G) the crushing strength of the plate in front of two rivets, plus the shearing strength of one rivet in single shear would be

$$(2 \times 0.9375 \times 0.4375 \times 95{,}000) + (1 \times 0.69029 \times 42{,}000) = 106{,}921 \text{ lb.}$$

As the least strength of the joint is due to consideration (F), namely, 111,328 lb., the efficiency would be

$$\frac{F}{A} = \frac{111{,}318}{144{,}375}, \text{ or } 77.1 \text{ per cent.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Model Boiler and Engineers' License Law--References

In the July 20 issue was published the model boiler-inspection and engineers'-license law, which was drawn up by a joint committee of the American Boiler Manufacturers' Association and the International Association of Tubular Boiler Manufacturers for the purpose of furthering uniform boiler legislation and securing the adoption of the Boiler Code of the American Society of Mechanical Engineers. The committee consisted of W. C. Connelly, president of the American Boiler Manufacturers' Association; C. V. Kellogg, president of the International Association of Tubular Boiler Manufacturers; S. F. Jeter, chief engineer of the Hartford Steam Boiler Inspection and Insurance Co., and F. R. Low, editor of *Power*. The law, as published, is a model after which legislative committees may pattern laws for their respective localities.

To further guide such committees the model law refers by numbers to references relative to the practice in various places. These references follow and in part include such information as the number of inspectors and number of boilers inspected per year, salaries and bonds of inspectors, inspection fees, office organization, requirements of chief inspectors, penalties, license-examination fees, disposition of moneys, etc. The numbers in these references correspond to the numbers given in the model law as published in the July 20 issue.

Under our form of government, the largest political unit which can undertake such supervision of steam-plant apparatus and its attendants as we seek, is the state. The Federal Government has already assumed the supervision of boilers used in international and interstate commerce and the examination and licensing of men in charge of them (Sec. 4405 Revised Statutes U. S.), inspection of interstate railway locomotives (Public No. 383 S. 6702) (Public No. 318 Hr. 17, 894, approved Mar. 4, 1915), but cannot establish and enforce safety requirements for stationary boilers and engineers except in the territories and the District of Columbia without infringing the sovereignty of the state. It has already done this for the District of Columbia and the Philippines.

1. Consult the constitution of the particular state for which the law is intended with regard to the title. Some state constitutions require the title to state specifically the object of the act, for such a state such a title as "An act for the prevention of loss of life and property by boiler explosions and accidents to power-plant operators" might be held to be too general, although it would be preferable from our point of view. One thing that the law provides for, the investigation of serious accidents to boilers and power plant apparatus—flywheel explosions, etc.—has been omitted from the title as proposed, in the interest of brevity and simplicity and because it is really a means for enabling the chief inspector to indefinitely determine what is necessary in carrying out the main provisions and effecting the main purpose of the law—the insuring of the public safety—but it may be necessary, in some states at least, to include this in the title.

2. Give the governor time to find his man. If the chief inspector is already determined upon, the time may be short. If he must be selected as the result of a civil-service examination, enough time must be allowed.

3. Some states may want to make the carrying out of the purpose of this act a function of an existing department instead of creating an entirely new one. In Massachusetts the inspection of boilers and licensing of engineers is done under the direction of the District Police; in New York City by the Boiler Squad of the Police Department; in Wisconsin and Ohio by Industrial Commissions.

In New York State boilers are inspected by the factory inspector; in New Jersey engineers are examined by the commissioner of labor. In this case, the law empowering such department or official may take an altogether different form or this model may serve by inserting at 3 for "governor" the name of the head of the department of which the inspecting of boilers or the examination of engineers is to become a function, as, for instance, "factory inspector," "commissioner of labor," etc.

4. It is hardly worth while, unless it is required, to make the governor's appointment subject to the approval of the legislative branch, but it may be advisable to make the appointment by a commissioner subject to the approval of the governor.

5. There may be various ideas as to the eligibility of the chief inspector. When practicable, he should be appointed through a civil-service examination. Massachusetts requires at least three candidates to get at least 80 per cent. on such an examination. This precludes killing off or freezing out candidates by an over-difficult or over-specialized list of questions. The requirements for eligibility as chief of the department under existing laws are:

Massachusetts—Qualifications not stated.

Ohio—Not less than ten years' experience as practical steam engineer. Section repealed.

Wisconsin—By examination prescribed by Industrial Commission.

Indiana—Qualifications determined by the State Board of Inspection.

Montana—Ten years' experience in operation of boilers, and for five years previous to appointment must have held Montana first-class engineer's license.

Minnesota—Qualified by experience in construction of steam boilers, and ten years' experience operating steam engine and boilers.

Colorado—Practical experience in use and construction of boilers, engines, superheaters, generators, and their appurtenances.

Connecticut—"Shall appoint in each congressional district a suitable person * * *"

Chicago—Practical experience in design, construction and operation of boilers, generators and superheaters and their appurtenances. Practical experience in design, construction and operation of manufacturing houses, or any factory or place wherein the piping, machinery or apparatus is under pressure.

Denver—Practical experience in design, construction and operation of boilers, generators, superheaters, elevators and their appurtenances.

Detroit—Ten years' experience in operation of boilers. Knowledge of construction and operation.

Pittsburgh—Not less than ten years' experience in operating steam machinery and not less than five as practical stationary engineer.

Philadelphia—"* * * person skillful and competent for the discharge of the duties hereinafter directed * * *"

New Jersey—Citizen of state engaged for at least ten years as engineer in charge of plant of not less than 250 hp., or as boiler inspector for company licensed to do business in the state. Approved by Civil Service Commission.

St. Louis—Practical mechanical engineer.

6. The office created by this act requires a man of considerable ability, and an executive as well as a practical boiler man and engineer, and is rather more important than the usual inspectorship, the salaries attaching to which under existing laws are as follows:

Massachusetts	$2400
Ohio (repealed)	$3000
Wisconsin	Not stated
Indiana	$2000
Montana	2500
Minnesota	Fees retained
Colorado	$2500
New Jersey	1200
Chicago	Not stated
Denver	$1800
Pittsburgh (Allegheny County)	Fees retained
Detroit	$1800
St. Louis	3000
New York City	2250
Kansas City, Mo.	1500

7. Some laws provide for office space in a department or commission already established.

8. The majority of boilers in any state are already under inspection by the insurance companies and would be taken care of by Sec. 4. The number of inspectors, chiefs included,

employed and the number of boilers inspected under existing laws are as follows:

Place	No. of Inspectors	No. of Boilers Inspected per Year
New York City	10	14,257
Philadelphia	7	7,341
Massachusetts	24	6,746
St. Louis	5	2,063
Pittsburgh (Allegheny County)	7	7,610
Indiana	6	7,500
Denver	3	1,496
Ohio	10	5,000

9. The number of examiners under existing laws in some places is as follows:

Place	No. of Examiners	No. of Licenses Issued and Renewed
New York City*	2	13,969
Ohio*	12	18,152
New Jersey*	3	15,000†
Spokane	1	687
Massachusetts	24	2,955

*Examiners do not inspect boilers. †New department, licenses issued without examination first year.

10. The salaries paid to inspectors and examiners under existing laws are as follows:

Massachusetts	$1750
Ohio (section repealed)	$2000 and $1800
Wisconsin	Not stated
Indiana	$1500
Montana	2100
Minnesota	Fees retained
Colorado	$1800
New Jersey	1200
Chicago	Not stated
Denver	$1200
Pittsburgh	1500
Detroit	1100
St. Louis	1200
New York City	1400
Kansas City, Mo.	per day, $3

11. Perhaps there is some better way of putting a bound to the patronage of the chief's office than to put a limit in the fundamental law, and require amendment as the office increases. An annual appropriation of which this act might carry the first, may be practicable and better than the suggested form. Some states name the salary in the act and require that the appointment be made only when authorized or approved by the governor or other such authority as the industrial commission, factory inspector, etc.

12. Two weeks to thirty days usually gives an owner time to make the necessary arrangement for competent licensed attendants.

13. In Massachusetts the lack of uniformity in examinations has been one of the things that has caused much of the opposition to the engineers' license law in that state; such opposition having come from the engineers as much as from the employers.

14. Insert the name of the proper court.

15. Insert date at least six months off, giving time for the organization of the department and the necessary preliminary inspecting.

16. Care should be taken not to make the provisions of licensing engineers too onerous by requiring a licensed man for each small engine during each shift, while one licensed man might oversee personally or through his subordinates a number of engines not widely separated.

17. The penalties must accord with the state law which limits the penalties for misdemeanors. The law might specify what is a separate offense, so that a man might not run for months on a single fine. The penalties under existing laws are as follows:

Massachusetts—Violation of any provision of act punishable by fine of $20 to $500, or by imprisonment of not more than six months, or by both fine and imprisonment.

Ohio—Fine not less than $25 nor more than $500.

Wisconsin—Fine not less than $10 nor more than $100.

Indiana—For lack of appurtenances, fine $10 to $25. For other violations, $25 to $100.

Montana—Six specific penalties, with fines ranging from $100 to $500 and imprisonment from two months to a year.

Minnesota—Five specific penalties, with fines from $10 to $200. For operating defective boiler person is liable to damages to persons or property resulting therefrom.

Connecticut—Three specific penalties, with fines from $200 to $1000 and imprisonment up to six months.

Colorado—Four specific penalties, with fines from $10 $1000 and imprisonment up to two years. If owner fails to have boiler ready for inspection as notified, he is liable to pay fees and expenses incurred by the inspector's visit.

Buffalo—Intoxication: License forfeited for not less than six months. Failure to employ licensed engineer: Fine of $10 to $250. For interfering with performance of engineer's duties: Fine of from $10 to $50.

Chicago—For allowing low water, disturbing spring of safety valve or otherwise neglecting duties or interfering, any person fined $25 to $100 for each offense. Before offering second-hand boiler, kettle, tank, vulcanizer, superheater, etc., for sale, without inspection before sale, fine $10 to $100. For violating any provision where no specific penalty is provided, fine $25 to $100 for each offense.

Philadelphia—Engineer's license revoked for dangerous neglect of duty.

Kansas City, Mo.—For violation of any provision, fine $1 to $500. Each day's violation a separate offense.

Memphis—For violation of any of provisions, fine $2 to $50.

St. Louis—For employing unlicensed engineer, fine $25 to $100. Engineer failing to comply with law, fine $10 to $25. For failure or refusal to have boiler inspected at least once each year, fine $25 to $200. For carrying more than pressure allowed by certificate, "owners or users or engineers" fined $50 to $300. For operating boiler condemned by inspector, "owners or users" fined $100 to $500.

Seattle—For violation of any provision, fine not exceeding $100, or imprisonment for 30 days, or both fine and imprisonment. For issuance of false report, false entry in inspection records, issuing certificate without thorough inspection, inspector is liable to 30 days' imprisonment, "and shall ever thereafter be ineligible to hold any office in the gift of the City of Seattle."

Detroit—For failure to comply with terms, conditions and provisions, fine not more than $25 for first offense and not more than $100 for "each and every" subsequent offense, or 30 days in House of Correction or both.

18. In cases of emergency an owner or management may allow a plant to operate so many days without a licensed attendant. This period varies in different places as follows:

Massachusetts	One week
Ohio	Not stated
Wisconsin	Not stated
Indiana	Not stated
Montana	Fifteen days
Minnesota	Not stated
Colorado	Thirty days
New Jersey	Thirty days
Denver	One week
Detroit	Not stated; assistant may be left in charge
Kansas City, Mo.	Three days
Seattle	Not stated
Spokane	Six days

19. No code, however well adapted to present needs and conditions, will stand for many years without the necessity of revision. It is the hope and purpose of its framers and advocates to have the Code of the American Society of Mechanical Engineers universally adopted, but the conditions of its adoption should be such as to not only allow of necessary revision from time to time, but to favor the universal and, as nearly as may be, the simultaneous adoption of any revisions which may be found desirable. If numerous states adopt the code and then start in to revise it, each in its own fashion, a condition may be produced more onerous than at present.

The American Society of Mechanical Engineers has continued the committee which drafted the Code for the purpose of considering and recommending revisions as they are proposed or necessity for them arises. If such revisions could, when adopted, automatically become effective wherever the Code was in use, uniformity would be effectively preserved, and from the character of the society and the committee, only conservative and intelligent revision might be expected. But while a state might adopt an existing code as a document of record, it might not constitutionally adopt a code with such revisions as may hereafter be made to the same by the society's committee, as this might be a delegation of legislative powers to a foreign body not permitted by its constitution.

In Massachusetts the regulations concerning boilers are promulgated by a Board of Boiler Rules, consisting of one representative each of the boiler-using, boiler-making, boiler-insuring interests and a stationary engineer, together with the chief of the boiler-inspection department, and this provision has been adopted by other states and municipalities which have based their practice upon that of Massachusetts. The law provides for regular public hearings by this board to consider changes in the regulations. With a standard code and the desirability of avoiding frequent erratic and local changes in it, the extension of this practice does not seem advisable. Perhaps the best thing to strive for is the adoption by each state of the Code as it stands, with the provision that it may be revised under the conditions necessary to make such revision valid by the responsible head of the department. This may require approval by the governor

or an industrial commission after publication and a public hearing; or may be possible only by legislative enactment, which the chief inspector could then recommend. The natural and desirable outcome would be a national convention attended by the heads of the boiler departments, where they might exchange experiences, compare statistics and agree upon such revisions as appear desirable in view of their experience in enforcing the Code, with an appreciation of the desirabilty of uniformity and a mutual understanding that any revision should be general.

20. The fees for inspection under existing laws are as follows:

Place	Internal and External First Boiler	Internal and External Second and More Boilers at Same Inspection
Massachusetts	$5	$5
Ohio	7	7
Wisconsin	5	5
Montana	10	5
Minnesota	3	2
Connecticut	5	5
New York State	5	5
New York City	2	2
Colorado	5	5
Denver	5	5
Detroit	3	3
Memphis	5	2.50
Seattle	5c. per hp.—12 sq.ft. H.S.—if under 300 hp.	3c. per hp. for all over 300 hp.
Chicago	5	3
Philadelphia	$3 for each boiler and 20c. for every sq.ft. grate surface.	
Pittsburgh (Allegheny Co.)	3	3
Kansas City, Mo.	5	5
St. Louis	5	5

21. The fees for examination for licenses under existing laws are as follows:

Place	First License	Renewal
Massachusetts	$1	$1
Ohio	2	2
Montana	1st class, $7.50; 2nd, $5; 3rd, $3.	.....
New Jersey	2	2
New York City	no charge	.....
Philadelphia	3	1
Detroit	1	1
Pittsburgh	3	1
Spokane	1st class, $5; 2nd, $4; 3rd, $3; 4th, $2.	1
Kansas City, Mo.	5	2.50

22. Shall the inspector's office keep its fees and pay its expenses out of them or turn them in and get its money on vouchers? If the latter, how often must the inspector turn his collections in and to whom if not to the state treasurer? Relative to this some of the existing laws are as follows:

Colorado—Sec. 7 Revised Statutes of Colorado: All moneys received by the inspector under the provisions of this act shall be paid into the State Treasury. He shall take a receipt for the same in duplicate form, one of which he shall deposit with the state auditor, the other to be retained by him in the office of the inspector.

Montana—Sec. 1656 Revised Codes of Montana: All moneys collected by virtue of the provisions of this article must be paid into the State Treasury at least as often as once in each month.

Ohio—Sec. 8: All fees collected and received by the district examiners from the issue of licenses and renewals of the same, shall be, on or before the 5th day of each month, remitted to the chief examiner at Columbus, together with a monthly report of the business of their offices. Said chief examiners shall pay into the treasury, to the credit of the general revenue fund, all moneys and fees by him received from the district examiners * * * on or before the 10th day of each month.

Massachusetts—No mention in law.

New Jersey—Sec. 9, Chap. 363, Laws of 1913. The fees received by the commissioner (commissioner of labor) for such licenses shall be paid into the State Treasury.

Denver—Sec. 14 of City Ordinance, July 1, 1906. All fees provided for in this ordinance shall be paid to the treasurer.

Kansas City, Mo.—On completion of inspection, inspector presents city treasurer with inspection certificate and report; the treasurer then issues a receipt to inspector, which receipt is equivalent to cash when accounting to comptroller. The treasurer collects cash from those having inspections made.

23. It is sometimes necessary to exempt agricultural boilers and engines used in isolated localities, and to issue to engineers who have been employed in their present positions a certain number of years a certificate without examination, good for that position only.

25. It is usual to exempt sizes used for residential heating or having a grate area not in excess of 6 sq.ft. Where gas is used as fuel and no grate surface is available for rating, a ratio of 20 to 1 would be a fair average to assume. Therefore, under such conditions heating surfaces in excess of 120 sq.ft. would come under inspection. The practice under existing laws is as follows:

Place	Pressure, Lb.per Sq.In.	Grate Surface, Sq.Ft.	Heating Surface, Sq.Ft.	Horse-power	Families in Apartment
Massachusetts	15	4	..	3	5
Ohio	15	..	..	..	..
Wisconsin	15	..	..	10	..
Indiana	15	4	..	..	5
Montana	..	..	..	5	..
St. Louis	25 hp. (15 heating)	75	..	..	..
Kansas Cy., Mo.	15	..	..	..	..
Chicago....City	Pressure	..	..	..	3
New Jersey	10	..	..	..	..
Memphis	15	..	..	3	..
Seattle	..	..	..	..	2

26. The kind of bond and to whom it is satisfactory as practiced in states having laws are as follows:

Place	Kind	Approved by
Colorado	Surety	Attorney-General
Montana	"Official"	Not stated
Ohio	"A bond"	Governor
Massachusetts	Surety	Governor
Denver	Surety	Mayor
Kansas City, Mo.	Surety	Comptroller
Philadelphia	Surety	Mayor

27. The amount of the bond required for inspectors and their assistants, as practiced in different places are as follows:

Place	Chief Inspectors	Assistant Inspectors	Clerk
Pittsburgh (Allegheny County)	$10,000	....	....
Philadelphia	10,000	....	....
St. Louis	10,000	$5000	....
Colorado	5,000	....	....
Montana	5,000	2500	$2000
Ohio	3,000	2000	1500
Massachusetts	3,000	3000	....
Denver	2,500	....	....
Kansas City, Mo.	3,000	1500	....

Pittsburgh Smoke Abatement

Representatives of nearly one hundred manufacturers met in Pittsburgh recently to discuss and evolve means for improving smoke conditions in that city. The Smoke and Dust Abatement League, the Mellon Institute, and the Civic Club of Allegheny County were also represented.

The meeting, one of a series J. W. Henderson, chief of the Pittsburgh Bureau of Smoke Regulation, is holding to disseminate information and encourage coöperation between his bureau and the users of apparatus giving off smoke, was devoted exclusively to considering smoke issuing from stationary stacks. Mr. Henderson, in an opening address, said that the interests responsible for smoke reduction are to be congratulated on the splendid results achieved, particularly during the past year.

The reports of the United States Weather Bureau show that during the first six months of 1915 the number of smoky days was 45 per cent. less than during the same period in 1912. With the increased activity of the mills during May and June, 1915, the drop in the number of smoky days is actually over 50 per cent. It was also found that in the days reported, the smoky period was short as compared with conditions in past years; that is, a diagram of the hours of smoke per month would indicate a more remarkable reduction. Perhaps the greatest accomplishment in smoke abatement in Pittsburgh is to be credited to the Crucible Steel Company of America. In one of its plants this concern replaced 55 old boilers with sixteen 300-hp. boilers. The eight stacks for the new installation have never been known to violate the Pittsburgh smoke ordinance. At an expenditure of $130,000 the company claims a saving of more than $60,000 yearly. If the Crucible Steel Co. will do as well with at least 95 per cent. of the rest of its stacks in the city, Pittsburgh smoke abatement will be practically accomplished.

Mr. Henderson mentioned a large number of installations that are demonstrating that smoke abatement can be made practically permanent, and suggested that the Mellon Institute duplicate the smoke survey made a couple of years ago. This would give additional facts to show that smoke abatement is not only possible, but is worth while from the standpoint of economy. On the conclusion of Mr. Henderson's address, the representatives present described what their plants were doing to promote smoke abatement. A number of devices used for smoke prevention were explained, and it was shown that Pittsburghers were spending a great deal of money in an earnest effort to make the city smokeless.

Effect of Relative Humidity on Leather Belts*

By WILLIAM W. BIRD† and FRANCIS W. ROYS‡

It has long been a recognized fact that the weather has a more or less noticeable effect on leather belts. In experimental work it has often been found impossible to duplicate results when testing the same belt on different days. In practice, those who are familiar with the behavior of leather belts have noticed a difference in their action from day to day, under varying conditions of the weather. However, when the generally accepted rules for belting are consulted, it will be found that the discussion of the weather has been entirely omitted for once. Of the several weather conditions which can be noted readily, it was thought that the variation of the relative humidity of the atmosphere would offer the most promising field, and therefore the effect of this variation was chosen as the subject for a special investigation.

After several months of preliminary work, with uncertain conclusions and very discouraging prospects, it was decided that, if anything definite was to result from the experiments, the effect of many of the variables would have to be eliminated by keeping most of the conditions constant.

The most noticeable effect of an increase in the humidity was found to be in the lengthening of the belt. If the distance between the pulley centers remained constant, this lengthening of the belt would decrease the sum of the tensions. On the other hand, the sum of the tensions could be maintained by varying the center distance as the humidity was changed. Thus the field being narrowed to these limited conditions of constant initial length—width, thickness and speed of the belt; diameters of the pulleys, horsepower transmitted, and temperature—the investigation was carried out to determine:

a. The effect produced on the center distance by varying the sum of the tensions, the relative humidity remaining constant.

b. The effect of the relative humidity on the center distance, the sum of the tensions remaining constant.

c. The effect of the relative humidity on the sum of the tensions, the center distance remaining constant.

A general layout of the apparatus used in these experiments, which were conducted at the Worcester Polytechnic Institute, is shown in Fig. 1. It may be described as follows:

A shaft, carrying a pulley on one end and an Alden dynamometer on the other, is mounted on a carriage that is free to move in a horizontal direction at right angles to the shaft. On the same level with this first shaft and parallel to it, is a jackshaft driven at constant speed. This jackshaft has a pulley on one end the same size as the pulley on the dynamometer shaft and the "belt under test" runs over these two pulleys. The Alden dynamometer furnishes the load which is equivalent to $T_1 - T_2$ or the difference between the tensions of the tight and slack sides and the platform scales weighs the sum of the belt tensions, or $T_1 + T_2$, as shown in the figure.

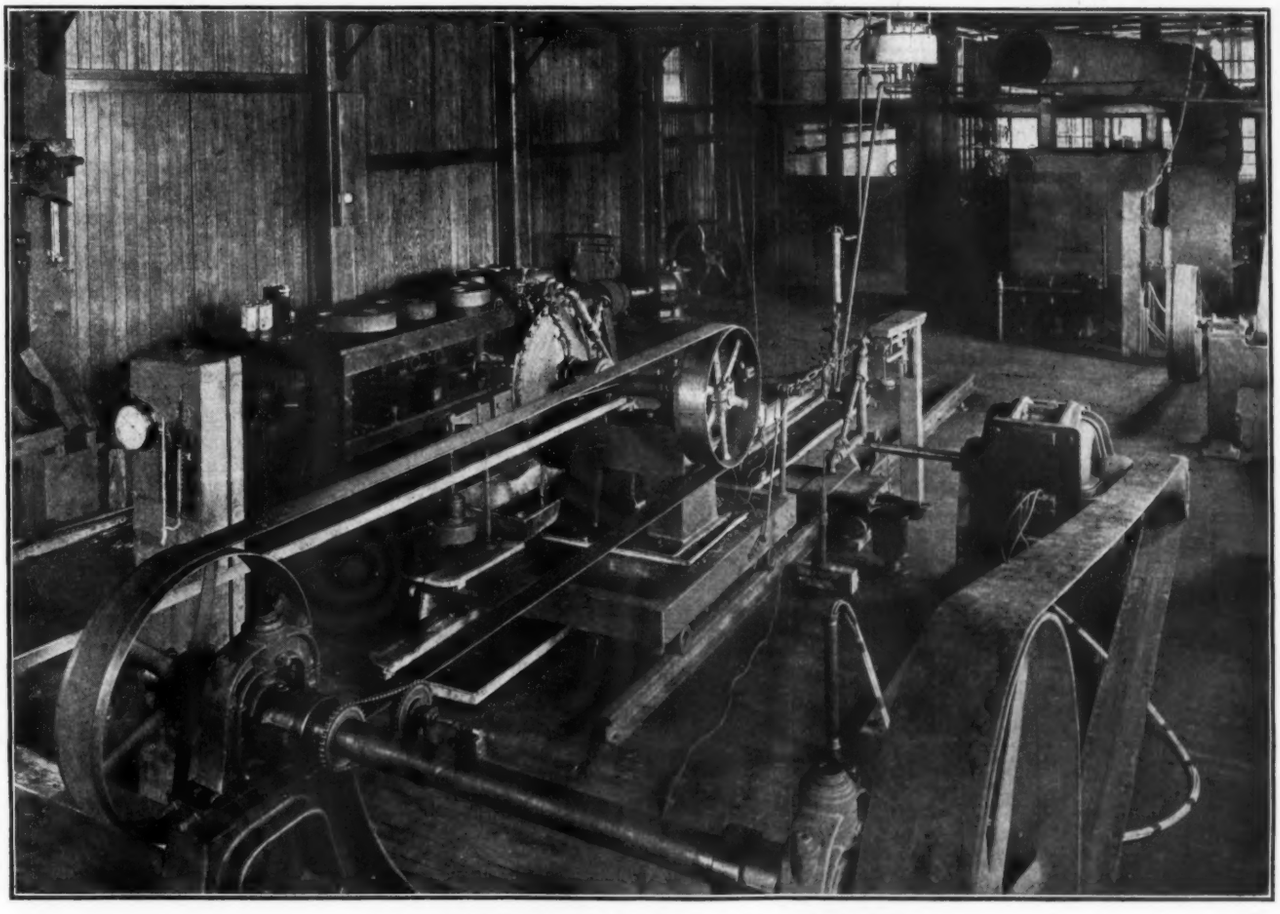


FIG. 1. GENERAL LAYOUT OF THE APPARATUS

In order to measure all of the power transmitted by the belt, the shaft bearings were so designed that they formed a part of the dynamometer. Fig. 2 shows this arrangement in more detail. The bearings consist of pairs of S. K. F. ball bearings in which the shaft turns. The ball bearings are carried in a housing which is free to turn inside of a pair of Standard roller bearings. Thus what little friction there may be in the ball bearings will tend to turn the housing, which is attached to the dynamometer casing and thereby becomes a part of it.

*Presented at the spring meeting, June, 1915, of the American Society of Mechanical Engineers.

†Director, Department Mechanical Engineering, Worcester Polytechnic Institute.

‡Worcester, Mass.

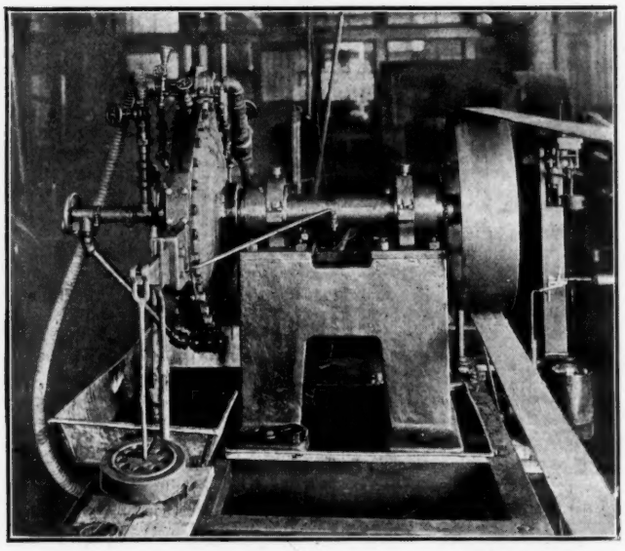


FIG. 2. DETAIL VIEW OF THE DYNAMOMETER

In the rear of the room, Fig. 1, is a Sturtevant heater and blower, the heater to keep the temperature under control and the blower to circulate the air in the room. A live-steam jet inside of the heater and a humidifier hung from an overhead beam were used for humidity control. The use of the humidifier had to be discontinued because it was found to give fog instead of true humidity and consistent results could not be obtained, while with the steam jet it was possible to duplicate results at any time. The degree of relative humidity was measured by a precision hygrometer of the hair type, a wet- and dry-bulb thermometer and a sling psychrometer, a modification of the pattern developed by the U. S. Weather Bureau, the last method giving very satisfactory results.

The belt used in this investigation was a 4-in., single, oak tanned leather belt furnished by the Graton & Knight Manufacturing Co., of Worcester. The pulleys were a pair of cast-iron crown-face pulleys, 24-in. in diameter with a 6-in. face. The initial length of the belt was such that the center distance at 20 per cent. humidity, $T_1 + T_2$ equaling 320 lb., was 9 ft. $6\frac{3}{16}$ in. This makes the belt approximately $25\frac{1}{2}$ ft. long.

Standard conditions were assumed to be $T_1 = 240$, or 60 lb. per in. of width, and $\frac{T_1}{T_2} = 3$, where T_1 = the tension in the tight side of the belt and T_2 the tension in slack side. This gives $T_1 - T_2 = 160$ lb., and as the belt speed remained constant at about 1900 ft. per min., the horsepower was approximately 9.21 all of the time. This condition will give between 0.8 and 0.9 per cent slip, or creep.

Experiments were run to see if a difference in the modulus of elasticity of the belt, when running, could be detected at 20 per cent. 55 per cent. and 90 per cent. humidity. These relations as found are shown in Fig. 3. Tests were also made at these humidities to see if a difference in the slip due to different values of the modulus of elasticity could be shown. No noticeable effect could be detected.

The results of the tests under the second condition are shown for three different values of $T_1 + T_2$ in Fig. 4.

The results of these two sets of experiments were investigated and plotted as a surface as shown in Fig. 5.

From Fig. 5 the data for the curves of Fig. 6 were taken. After these curves were drawn, experiments were performed and the circles shown in Fig. 6 indicate the results obtained. These results, as will be seen, were a very good check on the calculations.

The three black spots indicated on the surface of Fig. 5 all occur at $T_1 + T_2 = 320$ lb. Now, starting at any one of these points and keeping the center distance constant, take the course indicated by the line along which the printing occurs. This line is seen to cross the lines of constant tension, the tension increasing as the relative humidity decreases, or vice versa.

GENERAL CONCLUSIONS

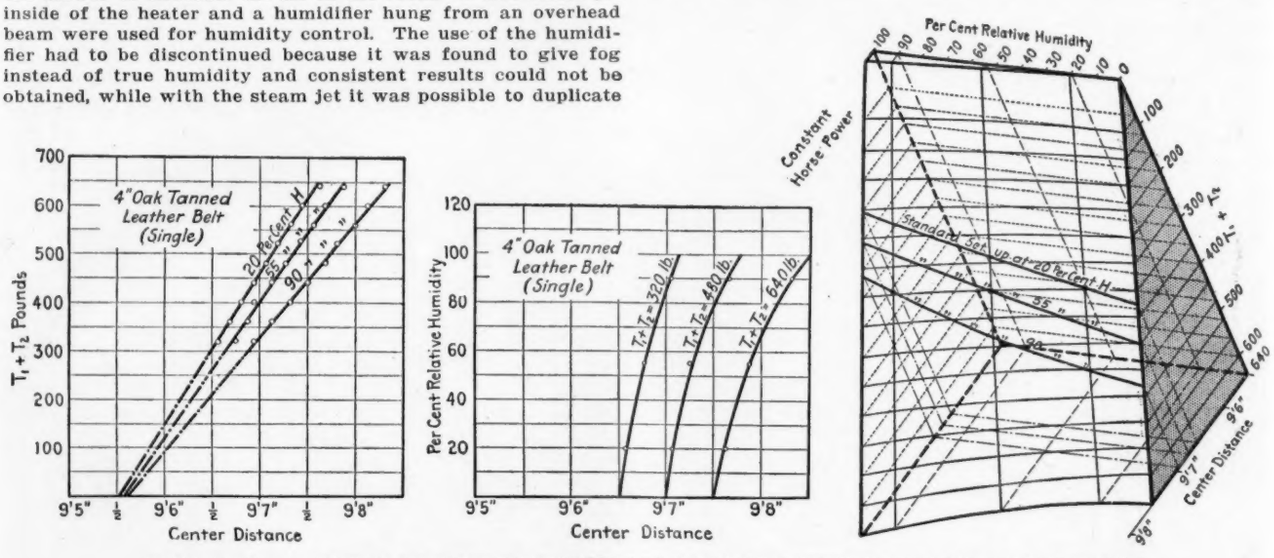
The surface shown in Fig. 5 might well be called the characteristic of this belt, and it indicates in a general way what might be expected from similar belts. Leather itself will vary; the tanning is different; the quantity and quality of belt dressing is never twice the same. All of the factors being more or less unknown, it will be impossible to make definite prediction regarding other belts.

However, in a general way it may be stated that the effect of a change in relative humidity is greater at high humidities than at low, that the effect is shown more rapidly in a single than in a double belt, and that increasing the humidity shows immediate results while a decrease in humidity takes some little time to be effective.

If a belt be set up at 20 per cent. humidity under standard conditions, the load remaining constant, and the center distance being fixed, an increase in the humidity will decrease the sum of the tensions, while the difference of the tensions will remain the same since the load is constant. Therefore, the ratio of the tensions, or $\frac{T_1}{T_2}$, will increase with the humidity, and at about 90 per cent. humidity the belt will be on the point of slipping. This variation is shown in Fig. 7. The data for the curve are taken from Fig. 5.

If the belt be set up at 90 per cent. relative humidity under standard conditions, a decrease in humidity will increase the sum of the tensions, provided the distance between centers remains constant. This will result in an excessive pressure on the bearings at low humidity and also tend to stretch the belt beyond the elastic limit. This is shown in Fig. 8, which is in reality a section of the surface in Fig. 5.

If the standard set up be made at 55 per cent. relative humidity, which is somewhere near the normal, any possible increase in relative humidity will not produce an excessive ratio of tensions, and any possible decrease in relative humidity will not cause an undue sum of tensions. Both of these relations are shown in Fig. 9.


4" Oak Tanned Leather Belt (Single)
$T_1 + T_2$ Pounds
Center Distance
Per Cent Relative Humidity
$T_1 + T_2 = 320$ lb.
$T_1 + T_2 = 480$ lb.
$T_1 + T_2 = 640$ lb.
Constant Horse Power
"Standard" Set up at 20 Per Cent H
55 "
90 "

FIGS. 3 TO 5. DIAGRAMS SHOWING VARIOUS RELATIONS UNDER DIFFERENT CONDITIONS

Fig. 3. Relation Between $T_1 + T_2$ and Center Distance at Three Conditions of Relative Humidity. Horsepower Constant. Fig. 4. Relation Between Per Cent. Relative Humidity and Center Distance at Three Conditions of $T_1 + T_2$ Horsepower Constant. Fig. 5. Belt Performance Surface for an Oak Tanned Leather Belt 4 in. Wide, Showing Relation Between Center Distance, Sum of Tensions and Per Cent. Relative Humidity.

As the higher relative humidities generally occur at temperatures above 70 deg., it was thought best to extend the field of investigation by varying the temperature. Accordingly a series of experiments was run at 50 deg. temperature with the relative humidity varying from 20 to 90 per cent. and another series at 90 deg. temperature, $T_1 + T_2$ and hp. being constant for all of these tests.

These results are shown in Fig. 10, which also has the corresponding results at 70 deg. from previous experiments. This would indicate that the belt lengthens as the temperature increases, the relative humidity remaining constant; that the amount of this lengthening of the belt is somewhat

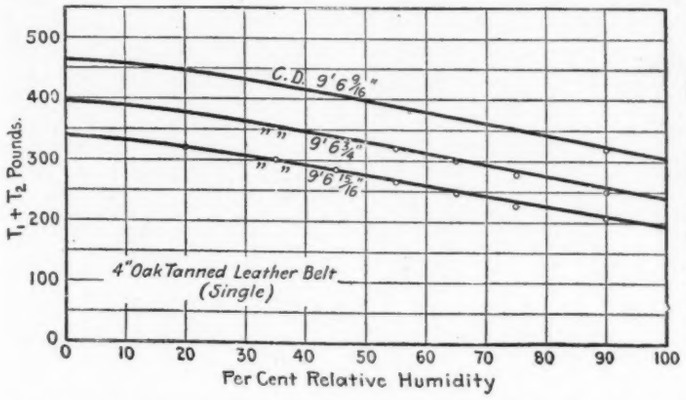


FIG. 6. RELATION BETWEEN $T_1 + T_2$ AND PER CENT. RELATIVE HUMIDITY FOR THREE CONDITIONS OF CENTER DISTANCE HORSEPOWER CONSTANT

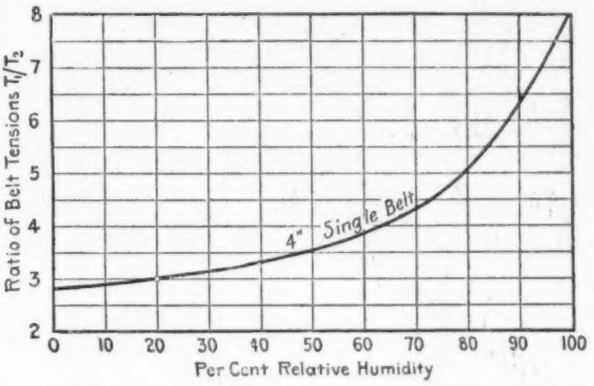


FIG. 7. EFFECT OF CHANGE OF HUMIDITY FROM 20 PER CENT., SHOWING THE INCREASED RATIO OF BELT TENSION HORSEPOWER CONSTANT

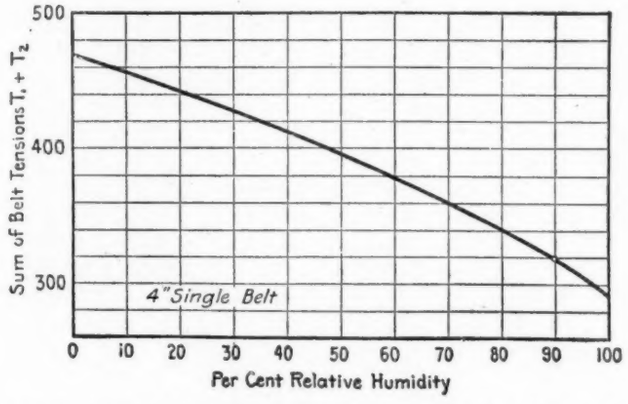


FIG. 8. EFFECT OF CHANGE OF HUMIDITY FROM 90 PER CENT. HORSEPOWER CONSTANT

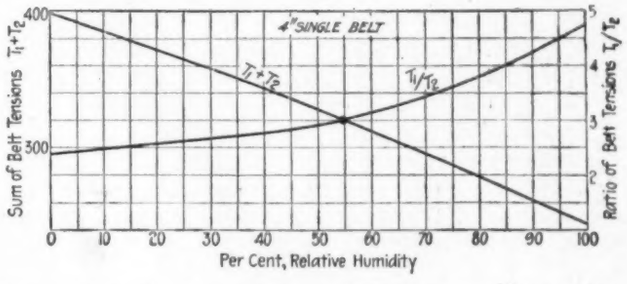


FIG. 9. EFFECT OF CHANGE OF HUMIDITY FROM 55 PER CENT. HORSEPOWER CONSTANT

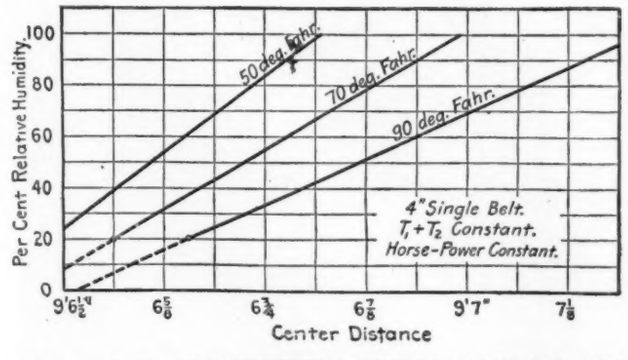


FIG. 10. RELATION BETWEEN CENTER DISTANCE AND RELATIVE HUMIDITY OF THREE DIFFERENT TEMPERATURES

greater at high relative humidities than at low relative humidities; and that the lengthening of the belt due to an increase in the relative humidity is greater at temperatures higher than 70 deg. and less for temperatures under 70 deg.

It would appear from our experiments that the lengthening of the belt which takes place when the humidity increases, is very nearly proportional to the relative humidity while no definite relation to absolute humidity exists.

The fact that the lines in Fig. 10 are not parallel would indicate that either there is some slight effect due to changes in the absolute humidity or, what is more probable, the coefficient of expansion is greater at 90 deg. than at 20 deg. temperature.

The general conclusions are:

If a belt be set up at low relative humidity, slipping will probably occur if the relative humidity increases to any great extent, especially if accompanied by a rise in temperature.

If a belt be set up at high relative humidity, excessive pressure on the bearings and stretching of the belt will result from a decided decrease in relative humidity, especially if accompanied by a fall in temperature. If a belt be set up at a medium relative humidity, the tensions will not be excessive at lower relative humidities, nor will there be any great danger of slipping at high relative humidities unless accompanied by excessive temperature changes. In other words, the factor of safety in the ordinary belt rules is sufficient to take care of the effect of changes in the relative humidity if the set-up be made at a medium per cent. of relative humidity.

If a belt be set up at any relative humidity with a spring or gravity tightener, a load 50 per cent. greater than the standard can be transmitted at either high or low humidity without danger of stretching the belt, slipping or excessive pressure on the bearings.

Protecting Synchronous Converters*

Railway synchronous converters when supplied from systems of large capacity are subject to more or less frequent troubles from flash-overs, thereby making it necessary to take precautionary measures to insure the protection of both operators and equipment.

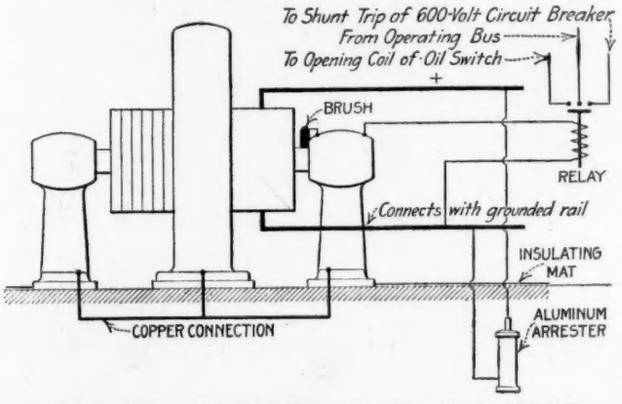
Flash-overs may occur at times coincident with system trouble, or sudden large changes in the load on a unit, or following a severe short-circuit on the 600-volt system close to the substation; they have also occurred with no apparent provocation. Those due to potential surges may be minimized or avoided by the use of electrolytic arresters. These arresters should be connected directly across the positive and

*From the report of the Committee on Electrical Apparatus of the National Electric Light Association.

negative leads and inside the series field connections in order to reduce the impedence of the discharge path to a minimum. Experience on one large system indicates that not less than one set of arresters of the proper number of cells should be installed to each 500 kw. of converter capacity it is desired to protect.

It is recommended that these arresters be connected directly to the machine circuit without an intervening spark-gap. A spark-gap would have the advantage of increasing the life of the aluminum parts, but would decrease the value of the protection. The former, however, is not of serious importance, as is indicated by the results obtained from numerous installations of similar arresters on electric-railway cars.

When the type of arrester is used employing a resistance to keep the potential across the arrester equally balanced, the



GROUNDING SCHEME FOR FRAME OF RAILWAY SYNCHRONOUS CONVERTERS

wear on the aluminum is very small, requiring renewals every year or two only, under ordinary conditions.

The efficiency of the aluminum arrester for this work is due to its safety-valve effect, its high discharge rate and its high capacities. When connected directly across the bus rings of the converter, kept continually charged to the normal voltage of the machine and having an extremely low internal resistance, the slightest rise in voltage causes a free and heavy discharge through the arrester, quickly and completely relieving the synchronous converter of dangerous surges.

Through its condenser effect high-frequency disturbances of limited quantity are absorbed. The condenser effect alone, however, cannot be depended upon, as no condenser of practical size is capable of absorbing the immense amount of electromagnetic energy which must be dissipated when a short-circuit occurs. Even with this protective installation, flash-overs have occurred on the alternating-current rings, and it may be necessary to provide spark-gaps between the secondary terminals of the step-down transformer and ground as an additional precaution, although the cause of such alternating-current flash-overs and the efficacy of spark-gaps as a cure have not as yet been proved. Spark-gaps, if installed, should have a limiting resistance in series with them of about 1700 ohms in each phase. As a further precaution and to minimize the extent of trouble which may follow a flash-over, it is desirable to insulate the frames of the units from ground and provide grounding connections as follows:

Grounding of machine frames may be accomplished either through a resistance to permanent ground or by some method giving equivalent results. The diagram represents a method now in use by some large companies for properly protecting railway synchronous converters. The frame is connected to the grounded rail through a relay operating through a circuit-breaker to disconnect the converter from the bus whenever an appreciable amount of current passes from the converter frame to ground.

It is relatively difficult to so insulate the frame of a machine as to control the amount of resistance between the frame and the ground when it is grouted in the foundation in the usual manner. The practice of mounting these machines on concrete foundations practically accomplishes the desired result, since, unless the machine is in actual contact with metal conduits or structural framework, the concrete surrounding the base forms a path of fairly high resistance from the frame to the ground. Care should be taken to insure that the frame of the machine is not in actual contact with some positive ground, nor sufficiently close for an arc to jump from the frame to a grounded structure. A minimum distance of at least one inch is recommended.

Oil-Burning Stand-By Plants*

By C. H. Delany

Stand-by plants have very different functions on different systems. For instance, on one hydro-electric system the stand-by plant may be used only during periods of water shortage, which would mean that it might be operated for one or two months during the year and completely shut down the rest of the time. Another system may use its stand-by plant at frequent intervals during the year, whenever there is an interruption of the hydro-electric service lasting long enough to enable the plant to be started up. A plant of this character would have to be ready for firing up quickly on receipt of notice that it was required, and an operating force would have to be on hand continuously for this purpose.

A third class of stand-by plant may be used to insure continuity of service at all times, and kept ready to pick up the load at any instant in case of a short-circuit on the transmission line or other slight trouble. A plant of this character must be kept operating continuously, even when it is not required to carry a load, and must be ready to pick up the load instantaneously on the throwing of a switch. The generating units and necessary auxiliaries must be kept operating up to speed, and there must be sufficient reserve boiler capacity cut in on the line ready to generate steam the instant the load is picked up. It is to plants of this character that this paper will refer, and it is in plants operated in this manner that the greatest advantage is found in oil fuel over coal.

Oil fuel on the Pacific Coast usually has a gravity of from 14 to 16 deg. Baumé and a heat value of approximately 18,500 B.t.u. per lb.

In comparison with coal, fuel oil not only has a much higher heat value, but it is possible to burn it much more efficiently. It is not uncommon with oil to maintain during plant operation a boiler efficiency approximating 80 per cent. while with coal, boilers in regular operation seldom show an average efficiency over 70 per cent. One barrel of oil containing 42 gal. is thus equivalent to about 500 lb. of good semibituminous coal containing 14,000 B.t.u. or to approximately 6500 lb. of a low-grade coal containing not over 11,000 B.t.u. per lb. At the present price of 70c. per barrel, therefore, our fuel costs are equivalent to paying $3.15 per ton for the best Eastern coal, or $2.40 per ton for a low-grade Western coal.

The oil is burned in a furnace similar to an ordinary hand-fired coal grate, except that the grates are covered with firebrick with spaces between them, placed so as to allow the air to enter directly under the flame at the points where it is most effective. In some cases the grates are omitted altogether and the firebrick are supported on pipes. The oil on reaching the boiler room, is heated to approximately 180 deg. and is delivered to the burners at a pressure of 40 to 50 lb. The oil is atomized in most cases by steam. In normal operation it is customary to use about 3 or 4 per cent. of the steam generated for atomizing, but by proper care in heating the oil and in the design of the burners and furnace, it is possible to reduce this to less than 1 per cent.

By careful arrangement of the air spaces between the brick laid on the grates, it is possible to obtain perfect combustion of fuel oil with not over 15 per cent. excess air, and it is due to the small amount of excess air required that the high efficiencies are obtained. The draft required is much less than when burning coal, because there is no draft used in pulling the air in through a thick bed of fuel. The most economical results are obtained when operating with zero draft in the furnace, so that only enough draft is required at the base of the stack to offset the friction losses in passing through the boiler setting and breeching. This will usually not exceed $\frac{1}{10}$ in. even at 200 per cent. of rating, so that unless

*From a paper read at the National Electric Light Association Convention, San Francisco, June 7-11.

economizers are installed, a stack 100 ft. high is ample for operating a boiler up to this capacity. By operating boilers with small draft the quantity of air filtering in through the brick setting is minimized, and this is another reason for the excellent efficiencies obtained when using oil fuel.

For stand-by plants perhaps the greatest advantage in the use of oil as fuel is the rapidity with which a fire can be started. It takes only about 30 sec. to light a torch, place it in the furnace and turn on the atomizing steam and the oil, and as soon as this is done a full fire is obtained. It is not uncommon to have a boiler started up with cold water ready to cut in on the line 30 min. after lighting the fire, and in cases of emergency this has been done in 25 min.

Another advantage that applies especially to stand-by plants is the fact that with oil fuel no banked fires are required. When the steam is not needed the fire is simply put out and the damper shut tight; then, by opening the damper and lighting the fire for a few minutes every hour, practically full boiler pressure may be maintained.

One disadvantage of oil fuel in a stand-by plant that is kept shut down most of the time is that it is necessary to maintain steam pressure for atomizing, so as to be ready to light the fires when the plant is called upon to carry the load. This compels keeping steam up on one boiler continuously, and as the boilers used in modern power plants are large, the loss due to radiation from this boiler is considerable. This difficulty, however, can be avoided by installing a small auxiliary boiler of 5- or 10-hp. capacity.

The belief is common that there is little or no accumulation of soot when burning oil. This is not the case, for while the quantity of soot is much less than in a coal-fired plant, it is still an ever-present evil, and it is necessary to dust the tubes at least once a day if the best efficiency is to be obtained.

THREE STAND-BY STEAM STATIONS

The Pacific Gas & Electric Co. is operating three stand-by steam stations at the present time—a 42,000-kw. plant in San Francisco, a 21,000-kw. plant in Oakland and a 5000-kw. plant in Sacramento. All are steam-turbine plants.

The San Francisco plant operates continuously and is of sufficient size to carry the entire San Francisco load. It is normally operated in parallel with the transmission system,

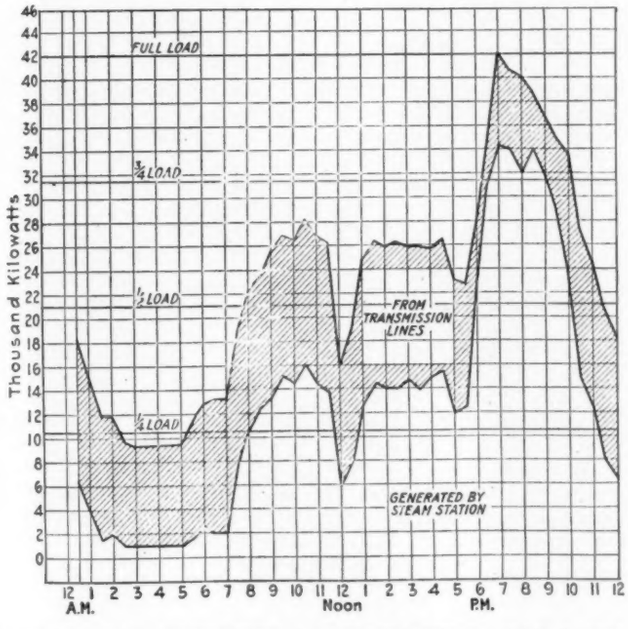


FIG. 1. LOAD ON STATION A, SAN FRANCISCO, MAR. 5, 1915

and a certain number of boilers are kept standing by, ready to pick up the load of the transmission system.

The method of operation is illustrated by the load curve, Fig. 1, showing the conditions as they existed on Mar. 5, 1915. In case of trouble on the transmission system the entire city load would be immediately thrown on the steam station, which means that during the day the load may jump instantaneously from approximately 14,000 to 26,000 kw., and during the evening peak the load may jump from 34,000 to 42,000 kw. It is, therefore, essential to keep enough boilers with steam up and cut in on the line, to instantly pick up this additional load. This can be done in two ways. First, by firing only sufficient boilers to carry the actual load on the plant, operating them at a constant capacity, and keeping the remaining boilers hot, with steam up, ready to be fired instantly when the load comes on; secondly, the full number of boilers necessary for the city load may be kept under fire continuously, operating at light load, but capable of being forced hard enough to carry the extra load when it comes on the station.

The latter method requires greater care in operation to insure proper regulation of the air supply with the wide variation of load on individual boilers, but it is more economical than the former method because a greater quantity of heating surface is in use with approximately the same amount

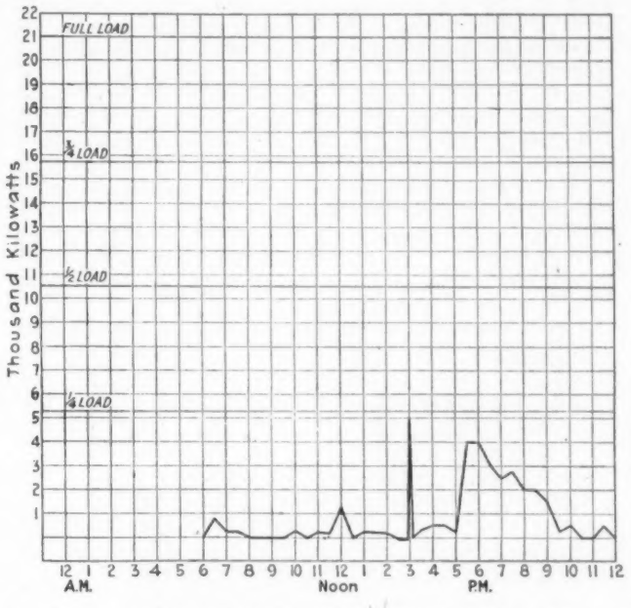


FIG. 2. LOAD ON OAKLAND STATION, DEC. 2, 1914

of radiation loss. This method, however, cannot be employed in the early morning hours, when there is a load of only 400 or 500 kw. on the station.

Experiments show that the smallest quantity of oil that can be burned with an oil burner of the size in use at this plant is about 280 lb. per hr. If an attempt is made to burn less than this the fire goes out. To insure good combustion and an even distribution of heat, it is advisable to operate with not less than two burners, and consequently each boiler will generate over 200 hp. if a fire is kept under it continuously. It is, therefore, essential to keep a number of boilers standing by with steam up but with the fires out, whenever the load on the station is very small.

The Oakland plant normally operates 19 hr. per day with one turbine floating on the line, generating not over 100 or 200 kw. except during the peak in the evening, when a load of approximately 6000 kw. is carried. In case of any minor trouble on the transmission system, this station instantaneously picks up a load of about 6500 kw., and if the difficulty continues this may, within two minutes, increase to 12,000 kw. The station may have to carry this load the rest of the day, although in the majority of cases the trouble is immediately isolated from the rest of the system, so that within two or three minutes the turbine can be switched back in parallel with the transmission system and the load drops again. There is no notice given of the load coming on; the only indication that the operators in the station have is the movement of the wattmeter needle and the steam-gage needle. This means that the wattmeter must be watched continuously so that the signal can be given to the firemen to light up their fires.

The station contains 12 boilers. Ordinarily, a light fire is carried under three, but in order to have all hot and ready to generate steam quickly, it is customary to fire the boilers alternately; that is, three boilers are kept under fire for three hours, and then three other boilers are fired up and the fires under the first three are put out. This rotation is continued throughout the day.

As soon as the whistle blows, signaling that a short-circuit has occurred, all the boilers except those down for cleaning or repairs are fired up. By careful training of the men in prompt action the entire operation of opening the dampers and ashpit doors, lighting burners from a torch and adjusting the oil and steam valves at the burners is accomplished in less than one minute. During this time the steam

pressure often drops 10 or 15 lb., but unless an unusually heavy load is picked up, normal pressure can be recovered within five minutes.

The station at Sacramento is used as a stand-by station in the same manner as the Oakland station except that when a short-circuit occurs the load picked up is often nearly the full capacity of the plant. In other words, the load on this plant frequently jumps from zero to full load instantly. This plant, which contains one 5000-kw. turbine, is operated by four

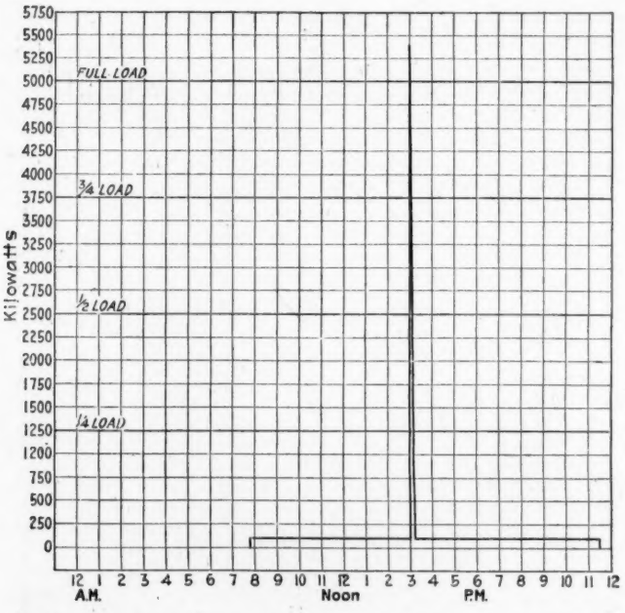


FIG. 3. LOAD ON SACRAMENTO PLANT, DEC. 2, 1914

boilers, one of which is kept cut out for cleaning; the other three are kept cut in on the line and are fired alternately so as to be kept hot.

An idea of the conditions of operation at the Oakland and Sacramento plants can best be obtained from a study of the load curves, Figs. 2 and 3. The curve for the Oakland plant for Dec. 2, 1914, shows about a normal load for this station.

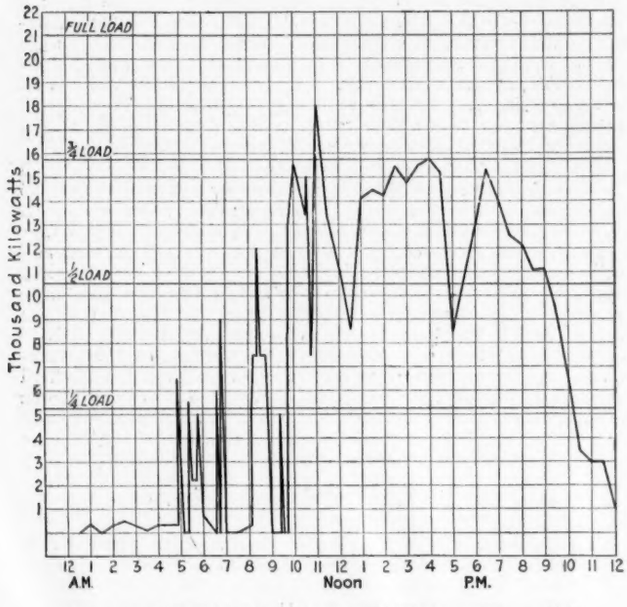


FIG. 4. LOAD ON OAKLAND STATION, FEB. 8, 1915

The turbine started up at 6 o'clock in the morning, ran along with little or no load until at 3 o'clock a short-circuit occurred which, however, lasted only a few minutes. This was the only disturbance during the day, the load dropping to zero again and remaining very small except during the evening hours. The load curve for the Sacramento plant on the same day shows no appreciable load except at 3 o'clock, when the same disturbance was felt at this plant. The disturbance appears more marked at Sacramento because the load picked up was greater in proportion to the size of the plant.

Figs. 4 and 5 show the load curves of these two plants for Feb. 8, 1915, illustrating the conditions of operation during unusually stormy weather when a great many disturbances occur on the transmission lines.

STAND-BY COSTS

To determine the amount of fuel-oil required to keep a boiler hot and ready for this stand-by service, tests were made on two boilers at the Oakland plant. In each case the boiler was warmed up slowly with a light fire; then the fire was put out, the stop valve was shut up and the boiler was allowed to stand. At the end of each hour the boiler was fired for a few minutes—long enough to bring the steam back to its original pressure. The oil burned each hour was weighed and the drop in pressure noted. The following are the results:

	750-hp. McNaull Boiler			773-hp. Parker Boiler		
	Steam Pressure, Lb. per Sq.In.		Oil Used	Steam Pressure, Lb. per Sq.In.		Oil Used
	Original	Final	lb.	Original	Final	lb.
First hour..	188	177	32	186	190	0
Second hour	188	172	43	190	183	4
Third hour.	188	169.5	53	186	169	25
Fourth hour	188	171	48	186	166	23
Fifth hour..	188	168	53	186	166	26
Average of last three hours....			51.3			24.6

The figures, 51.3 and 24.6 lb. per hr., amount to 3 and 1.4 per cent. respectively, of the oil required to operated the boiler at its rated capacity. The difference between the Parker boiler and the McNaull is due to the fact that while no pains were

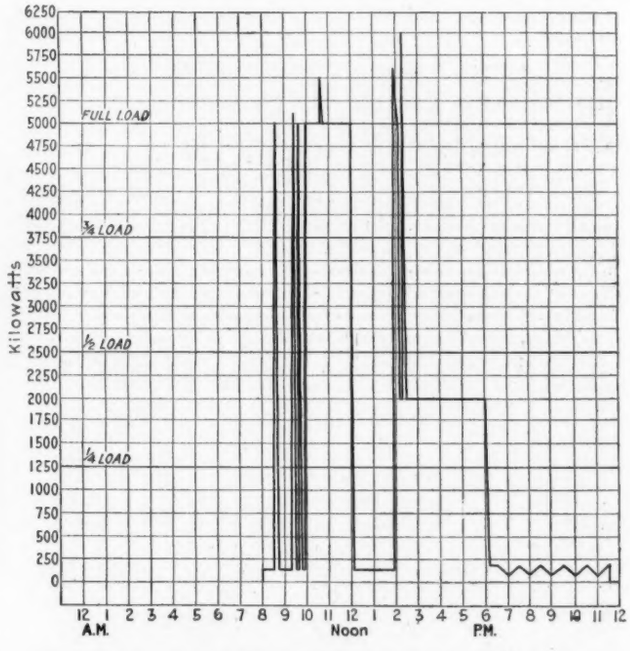


FIG. 5. LOAD ON SACRAMENTO PLANT, FEB. 8, 1915

taken on the latter to prevent leakage past the dampers, the Parker is fitted with a damper that can be shut tight.

Using the foregoing figures, the nine boilers in the Oakland plant use 381 lb. per hr., or 7240 lb. for the 19 hr. the plant is kept in operation. To this must be added about 1200 lb. to cover the warming up of the boilers after their 5-hr. shutdown, making a total of 8440 lb., or 25 bbl. of oil per day used solely for the purpose of keeping the extra boilers hot. This means a fuel cost of $17.50 per day, which could be saved if the stand-by did not involve being ready for full load instantaneously. In addition two extra men are required on account of the emergency condition, so that there is an expense of $700 per month more for the instantaneous stand-by service than for a service involving only the keeping of the turbine in operation.

It is the keeping of the turbine and its auxiliaries in operation, however, that is by far the largest expense in the operation of these plants. At the Sacramento station, for instance, a careful study of the regular plant records shows that it takes a little less than 5 bbl. of oil for 24 hr. to maintain pressure on one boiler and on the steam pipes throughout the station. This is the total fuel expense that would exist at this plant for stand-by service if it were possible to give the plant half an hour's notice when the load is coming

on. With the turbine and auxiliaries running at practically no load (less than 200 kw.), it requires 5.6 bbl. of oil per hour, which would amount to 135 bbl. in 24 hr. if the turbine were kept running continuously, as against 5 bbl. when the turbine is kept shut down. It is evident, therefore, that if it were not necessary to keep the machine in operation, the cost of operating the plant could be greatly reduced. It is for this reason that the turbine in the Sacramento plant is operated only at such times as are considered essential for the protection of the service.

Convention of Canadian A. S. E.

The Canadian Association of Stationary Engineers held its twenty-sixth annual convention at Hamilton, July 20-22, with headquarters at the Wentworth Arms Hotel. The attendance of delegates was larger than last year and there was a 50-per cent. increase in the number of exhibits. Convention sessions were held on the second floor of the National Drug Building, while the first floor of the same building was given over to the display of power-house equipment arranged by the Exhibitors' Association.

The opening exercises were held on Tuesday morning at 10:30, with President A. W. Heath, of Hamilton, in the chair. Controller Thomas Morris welcomed the delegates and guests to the city, and Past-President Samuel E. Cosford responded for the engineers. Alderman Plunket was the next speaker, and on behalf of the citizens of Hamilton he welcomed the visitors, and also described the commercial industries of the city. A. R. Bell, president of the Exhibitors' Association, responded for the supply men. R. H. Fox, of the Detroit N. A. S. E., next addressed the delegates, and was followed by A. M. Wickens, of Toronto, the "daddy' of the C. A. S. E. The delegates held a regular business session in the afternoon, and in the evening attended an entertainment and dance at the Sons of England Hall. James E. Fiddes, of the Standard Manufacturing Co., and Jack Armour, of "Power," entertained with the assistance of a company of local talent.

On Wednesday afternoon special cars carried the delegates and guests on a trip through the city, terminating at Dundurn Park, where outdoor sports were enjoyed. The ball game between the engineers and the supply men resulted in a victory for the former by a score of 7 to 6.

At the final session the election of officers for the ensuing year resulted as follows: Robert Dyson, of Guelph, president; William G. Forbes, of Montreal, vice-president; John Hale, of Hamilton, secretary; William E. Archer, of Toronto, treasurer; William E. Hooey, Owen Sound, conductor; Roger Gofton, Berlin, doorkeeper. These officers were installed by Past-President Cosford.

The newly elected officers of the Exhibitors' Association are: H. L. Peiler, president; C. G. Peterson, first vice-president; Lloyd Archibald, second vice-president; Gordon Keith, secretary; James E. Fiddes, treasurer; Earl F. Hetherington, chairman of exhibits; Edward L. Foley, chairman of reception committee; William R. Stavert, chairman of entertainment committee. Montreal was chosen for the meeting place in July, 1916.

The list of exhibitors follows:

Canadian Allis-Chalmers Co.
Canadian Automatic Wrench Co.
Canadian Griscom-Russell Co.
Canadian H. W. Johns-Manville Co.
Canadian Manufacturer Publishing Co.
Canadian Powers Regulator Co.
Canuck Supply Co.
Cling-Surface Co.
Cole Co., George W.
Darling Bros., Ltd.
Dart Union Co.
Dearborn Chemical Co.
Dixon Crucible Co., Joseph
Dunlop Tire & Rubber Goods Co.
Galt Foundry Co.
Garlock Packing Co.
Goldie & McCulloch Co.
Greene, Tweed & Co.
Hamilton Engine Packing Co.
Havre Engineering Co.
Imperial Oil Co.
Jenkins Bros.
Lunkenheimer Co.
MacLean Publishing Co.
Morrison Brass Manufacturing Co., James
National Drug Co.
Ontario Lubricating Co.
Peerless Rubber Manufacturing Co.
Peiler & Co., H. L.
"Power"
Quaker City Rubber Co.
Standard Sanitary Manufacturing Co.
Thompson-Gordon Co.
Turner, C. B.

DELEGATES AND VISITORS TO CANADIAN A. S. E. CONVENTION, HAMILTON, ONTARIO

Uniform Boiler Laws—Through the courtesy of Charles Thaddeus Terry, president of the Conference of Commissioners on Uniform State Laws, the Committee on Uniform Standard Boiler Specifications of the combined boiler manufacturers' associations will meet with the commission at the annual convention of the American Bar Association in Salt Lake City, in order to urge upon it the desirability of including the universal adoption of the American Society Code for steam boilers among the laws for the adoption of which it is striving.

Great Falls, Mont., claims the greatest available water power on the continent—350,000 hp. at the lowest average flow of water. There is now operating 75,000 hp., and 100,000 hp. more is being developed. Great Falls also has the biggest electric power house and the biggest smoke-stack in the world.

Control and Protection of Electric Systems*

By Charles P. Steinmetz†

When the first commercial electric circuit issued from a station the problem of control and of protection arose. It was a simple problem at first—an ammeter and voltmeter to measure current and voltage; a knife-blade switch to send the current into the desired path or withdraw it; the fuse to open the circuit in emergencies, and if the wires became crossed and the fuse and switch failed, the generator and engines stopped, and not much harm was done. With the extension of the circuits into the suburbs some lightning troubles were felt, which led to the introduction of lightning arresters.

Since those days, less than a generation ago, enormous changes have taken place, and the electric systems have increased in size, in voltage, and in extension. Where 100-hp. machines were large once, now turbo-alternators of over 40,000 hp. are in commercial operation. The steam engine has made room for the steam turbine, and the steam turbine does not stop when the wires are crossed and a short-circuit occurs; the momentum of the turbine disks, revolving at velocities of 300 to 400 miles per hour, can supply ample energy for the destruction of any part of the system. Attempts to open such circuits by the knife-blade switch of old would lead to the destruction of the switch, and probably its operator.

Instead of small machines operating separately on independent circuits, huge generators now feed in parallel into the system of busbars, on which is concentrated all the power of the station or the group of stations tied together. Numerous stations and systems of interconnected stations of 100,000 to a quarter-million horsepower and over are in operation, and the half-million horsepower mark has been reached.

Anywhere on the busbars of the station or in the feeders near the station there is available, destructively in case of an accident, as a short-circuit, not only the entire power of the station, but the far greater power which the station generators can give momentarily. Short-circuit currents of forty to fifty times normal full-load current may momentarily flow from some turbo-alternators, representing ten and more times full-load power. Such a station, or group of closely interconnected stations, of half a million horsepower full-load capacity, may momentarily send into a short-circuit at the busbars over five million horsepower. This is the power of Niagara, which is estimated variously at from 5,000,000 to 15,000,000 hp. It is obvious that no switch or circuit-breaker can be built to safely relieve such power.

With half a million horsepower station capacity, a momentary overload capacity ten times as high, assuming that we could build a circuit-breaker to open this short-circuit power as quickly as in three to four cycles, or one-eighth second, would require dissipating in the circuit-breaker the energy of over 200,000,000 ft.-lb.—the destructive energy of 1000 tons dropping from a height of 100 ft., that of a projectile weighing 2000 lb. leaving the cannon at a velocity of 2500 ft. per sec., or the destructive energy of two heavy railway trains, going at sixty miles per hour, and meeting head-on.

Equally great has been the increase of voltage. Where once 2000 volts was high, in circuits of a few miles in length, now circuits of over two hundred miles are in operation at 100,000 to 150,000 volts. Current at such voltages jumps toward an object over a foot distant, and will maintain arcs of practically unlimited distance; that is, with 100,000 volts and almost unlimited power back of it, an arc can extend for several hundred feet. Thus no simple switch will open a circuit at such voltages under power.

Lightning protection also has become a far larger problem than in the small circuits of old. But far greater than the energy of any lightning stroke is the energy stored as magnetic field surrounding the conductors and as dielectric field radiating from the conductors of these big transmission systems, and, if this internal energy of the system is set surging, its effects are far more destructive than those of lightning. The effects may not be merely momentary, as those of lightning, but continual, as machine energy keeps replacing the stored internal energy, which causes the destructive surge. The foremost problem of control of electric systems thus is that of controlling enormous powers; the foremost problem of protection is that against self-destruction by its own power.

Current and voltage have grown beyond the values for which instruments can be built, and current transformers and voltmeter transformers are interposed between the circuit and the instruments measuring it. With the general introduction of parallel operation, power-factor indicators are required to insure the division of load without excessive waste currents; and frequency indicators and synchronizing devices to safely connect machines into the system.

With hundreds of feeders radiating from the generating station, the office of the load dispatcher has become essential, and the necessity of keeping exact records of all operations and of all accidents and incidents is of the greatest importance. Automatic recording devices thus have been developed, as the multi-recorder, to record within fractional seconds all important events—opening and closing of switches, starting and stopping of generators, surges, lightning disturbances, etc. Such automatic devices afford a valuable check on the operating staff, but more important still is their record in emergencies. Where a number of things happen almost at once and the attention of the operator is distracted from accurate observation by the necessity of action, the record thus could be made only afterwards from memory. It is just in such abnormal conditions where the most complete and accurate record is of greatest importance, to enable the engineers to determine with certainty what happened and why it happened, so as to take steps to guard against its recurrence.

Oil circuit-breakers have been developed, which can safely and without disturbance close and open feeder circuits of over 10,000 hp. and generator circuits of 40,000 hp. In these the circuit is opened under oil so that at the instant of opening, the current is extinguished at the end of a half-wave by the rapid expansion and chilling of the oil vapor produced by the opening arc; this at first is under high compression, due to the momentum of the oil which has to be set in motion.

POWER-LIMITING REACTANCES

The possibility of self-destruction by the power let loose under short-circuit was solved by the development of the power-limiting reactances. In the generator leads, between generators and busbars, are inserted reactances capable of withstanding enormous overloads, but of a size sufficiently small not to interfere with the normal flow of power at full load or any overload that the generator may be called upon to carry. They are large enough, however, to materially limit the generator current and power on short-circuit. Usually the generator reactances limit the momentary short-circuit current to about ten to twelve times full-load current; that is, the momentary short-circuit power to about two and one-half times full-load power. This solved the problem for medium-sized stations.

However, even with generator reactances, with the increasing size of station, the power that may be let loose under short-circuit becomes large beyond control, and busbar reactances were next introduced. By such reactances in the busbars and in the tie feeders between the stations, the system is divided into sections of about 60,000 hp. each. A short-circuit then can seriously involve one busbar section only.

With hundreds of feeders radiating from the busbars, the probability of a short-circuit in the feeders is far greater than in the busbars, and a material advantage, therefore, is given by feeder reactances.

By the development of generator reactances, busbar reactances, and feeder reactance the problem of the power control of large systems for protection against self-destruction by short-circuit has been solved and unlimited extension of systems without any increase of danger has been made possible; and experience has shown that after the introduction of such power-limiting reactances dead short-circuits have occurred at the busbars of very large systems without even interfering with the operation of most of the synchronous apparatus on the system.

GROUNDS AND SHORT-CIRCUITS BETWEEN PHASES

The two main sources of trouble in lines and cables are grounds and short-circuits between phases. In transmission lines a ground on one phase is the most frequent trouble, and short-circuits are rare except in lines in which the design is faulty or reliability has been sacrificed to cheapness. A short-circuit is far more serious than a ground, as in the former the current is limited only by the generator capac-

*From a paper presented at a joint meeting of the Philadelphia Section, A. I. E. E. and the Franklin Institute and printed in the July "Journal" of the Institute.

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ity, while with a ground the current has no return unless the neutral is grounded, and then over the resistance of the neutral. In a well-designed transmission line a short-circuit usually occurs only as the result of two simultaneous grounds. A ground on one conductor, however, raises the voltage to ground of the other two phases, from the Y voltage to the delta voltage of the system, and thereby increases the strain on the insulation of the other two phases. It thus introduces the danger of a second ground, causing a short-circuit, or requires higher insulation.

This has led to two methods of operation of transmission systems. In the first, the neutral of the transformers is grounded, frequently through a resistance, where the resistance of the ground is not high enough to limit the current. Then a ground on one phase is a partial short-circuit to the neutral, causing a large current to flow, and thereby opening the circuit-breakers before the ground has developed into a short-circuit. However, this method, the grounded Y system, means a shutdown at every ground, every flashover of an insulator by lightning, etc. In the second method the neutral is not grounded, but the insulation of the circuit is good enough to safely stand the increased strain put on it by a ground on one phase, and by means of an arcing ground suppressor, etc., care is taken not to continue the arcing ground, leading to high-frequency disturbances, but convert it into a metallic ground. In this case the "isolated delta" system can be maintained in service, even if one phase grounds, until arrangements are made to take care of the load or the fault is found and remedied. However, the cost of line construction is higher, because of the better insulation required. The relation between grounded Y and isolated delta is one of cheapness versus reliability and continuity of operation.

PROTECTING UNDERGROUND CABLES

Different are the conditions in underground cable systems. In a cable the three conductors are so close together that a ground on one conductor quickly reaches the others and becomes a short-circuit. A grounded cable, therefore, cannot be kept in service, but has to be cut out promptly. In these systems it is customary to ground the neutral through a resistance sufficiently low, in case of a ground on one conductor of a cable, to allow enough current to flow to open the circuit-breaker and cut off the cable, but not sufficient to give a severe shock to the system. Or, where grounding of the neutral is considered undesirable, an arrangement of relays is made to give the same effect. With underground cables such cutting off of a disabled feeder does not interfere with the continuity of service, as a number of feeder cables are always used in multiple for every important substation.

However, the problem of cutting off a disabled feeder by the operation of the circuit-breaker, owing to the large current taken by the grounded feeder, is not so simple. Therefore, so-called "inverse time-limit" circuit-breakers are generally used; that is, circuit-breakers in which the time limit of their operation decreases with increasing overload. Such circuit-breakers would first cut off the cable carrying the greatest excess current—that is, the faulty cable—and then those of less excess current; but, as the excess current stops with the cutting off of the faulty cable at both ends, other cables should not be interfered with. However, the inverse time-limit circuit-breaker necessarily must be practically instantaneous under short-circuit, and therefore, while the time limit discriminates between 100 per cent. or 200 per cent. or 300 per cent. overload, it cannot discriminate between short-circuits of different magnitude.

Thus devices become necessary for selecting a disabled feeder and cutting it out without cutting off its parallel feeders or the tie feeders to the substation served by the faulty feeder, regardless of what excess currents these may carry. This is a problem that has not yet been completely solved.

In general, in high-power systems of high standard of reliability the radial system of substation supply is used; that is, each substation is fed by a separate set of cables, and the substations are not interconnected into a network by a system of tie feeders. This radial system, however, is less economical in feeder copper than the interconnected network, since the radial system requires for each substation a feeder capacity equal to the maximum power demand of the individual substation, while in the network, by cross-feeding between the substations, the feeder capacity is reduced to that required by the average maximum demand of the substations. Because of the economic disadvantage of the radial system, an effective selective feeder relay that could be relied upon to pick out the faulty feeder and no other would offer material advantages.

Such a selective device is afforded by the use of pilot cables. Each cable or feeder is duplicated by a smaller low-voltage, three-phase cable, which joins the secondaries of current transformers connected into the two ends of the main cable. If the main cable is undamaged, the same current comes out of it as flows into it, and the connections to the pilot cable are such that in this case the secondary currents would be in opposition; that is, neutralize each other. If, however, the main cable grounds, current flows into it from both sides, the secondary currents in the pilot cable then add, and the current flowing in the pilot cable operates the relay which opens the circuit-breaker. This arrangement is very perfect in operation, and is capable of cutting out the damaged cable without interfering with any other, but it has the disadvantage of doubling the number of cables required in the system. While the pilot cables are small and of low voltage, they occupy room in the underground ducts; hence, this method of control is little used in this country.

Another method is that of the split-conductor cable. Every cable conductor is made of two parts, of which the one surrounds the other concentrically, with some insulation between them. Normally there is no potential difference between the inner and the outer half of the conductor, as they are connected with each other at the ends of the cable. If, however, a ground occurs on the cable, this ground can at first reach only the outer half of the conductor, and a potential difference and current appears between the inner and the outer half of the conductor and operates the circuit-breakers through a relay connected between the halves of the conductor, at either end of the cable. This method also works very satisfactorily, but has the same economic disadvantage, though to a lesser degree than the method of pilot cables, in that the split-conductor cable is materially larger and more expensive.

The usual method of taking care of the problem, at least in most cases, is by the so-called reverse-power relay, also wrongly called "reverse-current relay." Such a reverse-power relay operates perfectly so long as there is any voltage for the reverse current to act upon. If, however, a short-circuit occurs at or close to the substation, the voltage vanishes, and with it the reverse-power relay loses its pull. To guard against this the installation of reactances is recommended between cables and substations to give a sufficient voltage drop to operate the relay. However, this is an additional complication.

The reverse-power relay is not adapted to guard the feeders between stations, as in these the current reverses in direction with the change of the distribution of load between the substations. Thus the reverse-power relay does not make the operation of interconnected networks of substations possible, but in the radial system of operation it is the only device which is generally available economically, and it is very satisfactory with the exception that it cannot operate where there is no voltage left.

LIGHTNING INTERFERENCE

Interference by lightning, with high-potential transmission lines, has rather decreased with increasing line voltage. In 100,000-volt lines the insulators are tested for one minute at 200,000 to 250,000 volts and stand momentarily for the very short time of lightning, over half a million volts. Thus it is rare that lightning flashes over or punctures the suspension insulators of our very high-voltage transmission systems. A flashover, with the grounded Y system, shuts down the circuit, often without any damage, while with the isolated delta system it may not even shut down the circuit, but is taken care of by the protective device against flashovers—the arcing ground suppressor in the station. Most lightning voltages incapable of destroying the line insulation run along the line until their energy is dissipated or they reach a station, and there they often do serious damage. The most important problem of lightning protection thus has become the rapid damping out of line disturbances caused by lightning, so as to make them harmless before they reach the station. The most effective method has been the overhead ground wire. By its screenings effect it lowers the voltage which lightning can induce in the line, but far more important is its powerful damping effect on the line disturbance—the traveling wave caused by lightning which runs toward the station.

In considering the protection of modern electrical systems it must be realized that the various sources and kinds of interference or danger require correspondingly different protective devices. It would be just as unreasonable to expect a standard type of "lightning arrester" to protect an electric system against all possible troubles as it would be to call for a single-standard "safety device" which would protect a railway train against all possible dangers, from a broken rail or a washout to a collision or a boiler explosion.

New Morrison Hotel Plant—In the table, page 114, of July 27 issue, of the principal equipment of this hotel, the maker of the three closed heaters should have been given as the Alberger Heater Co.

ENGINEERING AFFAIRS

The Pennsylvania State College will conduct a summer school of scientific management during the two weeks beginning Aug. 9. This session is planned for the accommodation of works managers, superintendents, heads and members of such departments as costs, stores, purchasing, planning and production. The mornings will be devoted to lectures and discussions on industrial organization and scientific management, under the leadership of Prof. Hugo Diemer; and the afternoons to actual practice in applied methods of scientific management, in the making of time studies, tool lists, construction cards, routing and scheduling, under the direction of W. H. Tabor. Application should be made to J. A. Moyer, Director, State College, Pennsylvania.

American Electric Railway Association—The 1915 convention of the American Electric Railway Association, at San Francisco, Oct. 4-8, promises to be one of the most important and interesting in the history of the organization. Some of the distinguished speakers will be Governor Hiram W. Johnson, of California, who will deliver the address of welcome; ex-Senator Jonathan Bourne, Jr., who will discuss government ownership; Bion J. Arnold, formerly chief engineer and chairman of the Board of Supervising Engineers in the rebuilding of the Chicago traction system and now chairman of the board, as well as consulting engineer of the Public Service Commission of New York City on matters connected with subway and street-railway properties, and of the Detroit United Railway and for the cities of Pittsburgh, Providence, Los Angeles, San Francisco and Kansas City, Mo., who will talk on the fundamental principles of the valuation of electric railways; Jesse W. Lilienthal, president of the United Railways of San Francisco, who will discuss welfare work; and Ivy L. Lee, formerly executive assistant to the president of the Pennsylvania R.R. and now of the personal staff of John D. Rockefeller, whose topic will be "Putting Publicity Theories Into Practice." There will also be reports from some 64 different committees of the association.

PERSONALS

Frank A. Simonds, formerly with the Simonds Heating & Specialty Co., Grand Rapids, Mich., has opened an office at No. 314 Shepard Building, Grand Rapids, and aside from his consulting steam engineering, is selling a line of power- and heating-plant equipment.

John Todd, sales manager, Garlock Packing Co., Palmyra, N. Y., met with an automobile accident July 15 in Rochester. Although he suffered severe injuries, his friends will be glad to know that he is now out of danger, at the Hahnemann Hospital in Rochester, and that his speedy recovery is expected.

William E. Moore has resigned as vice-president and general manager of the West Penn Traction Co., Pittsburgh. His services with that company date back to 1903. Before that time he had been engaged in developing railway and lighting properties in the South. Mr. Moore will act in an advisory capacity to the West Penn company and will also engage in general consulting engineering practice, covering power plants and transmission, car shops and railway engineering. He will also undertake appraisals, property examinations for financing purposes, problems arising through public-service regulations and advisory work in connection with public-utility management.

NEW EQUIPMENT

ATLANTIC COAST STATES

It is reported that D. L. Judkins, Barnet, Vt. plans to construct a power house on the bank of the Stevens River.

The Connecticut Power Co., 50 Congress St., Boston, Mass., has been granted a permit by the Town Council for the construction of a distributing station on Hazel St., Lincoln, R. I. This station will have an output of 25,000 kw. which will be distributed in Pawtucket, Providence and other towns and cities in the Blackstone Valley.

Press reports state that the Newburyport Gas & Electric Co., Newburyport, Mass., has applied for permission to erect a transmission line from Pipestave Hill to the Groveland line.

Press reports state that the La Fargeville Electric Light Co., La Fargeville, N. Y., has petitioned the Public Service Commission for permission to construct electric-light plants in Theresa and New Orleans.

SOUTHERN STATES

Plans are being considered for the construction of a power plant, capable of developing 600 hp., at the State Hospital for Insane, Columbia, S. C.

The Southern Power Co., Salisbury, N. C., will soon start work on the construction of a steel tower electric transmission line from Salisbury to Statesville.

The citizens of Oxford, Mass., have voted to issue $6500 in bonds, the proceeds of which will be used to improve the electric-light plant.

CENTRAL STATES

Bids will soon be received by H. Whitford Jones, Engr., 1392 Citizens Bldg., Cleveland, Ohio, for furnishing engines, generators and condensers for the municipal electric-light plant at Painesville, Ohio.

It is reported that bids are being received by Ernest McGeorge, Engr., 855 Leader News Bldg., Cuyahoga Falls, Ohio, for the construction of a one-story, brick and steel power house for the Fall Rubber Co.

Press reports state that the Board of Public Works, Coldwater, Mich., contemplates the purchase of a new 350-kw. generator and engine. K. E. Norton is Supt.

The Wiscinsin Minnesota Light & Power Co., La Crosse, Wis., plans an expenditure of about $210,000 for the improvement of its plant. J. N. Moncreiff is Mgr.

WEST OF THE MISSISSIPPI

A bond issue of $8000 has been voted by the citizens of Everet, Kan., the proceeds of which will be used for the installation of an electric-light system.

Plans are being prepared and bids will soon be received for the construction of an electric-light plant at Hale, Mo.

The Superintendent of Public Buildings and Grounds, Austin, Tex., has announced that about $100,00 will be spent in installing a power and heating plant in the State Capitol.

It is reported that the Puget Sound Light & Power Co., Seattle, Wash., will expend about $30,000 for the construction of a new system.

It is reported that the City Council of Burns, Ore., has passed a resolution authorizing the sale of $10,000 in bonds, the proceeds of which will be used for the construction of an electric-light plant.

The Western States Gas & Electric Co., Placerville, Calif., plans to enlarge its hydro-electric plant. The estimated cost is $75,000.

The Tulare Power Co., Visalia, Calif., plans to construct additions and make improvements to its plant at Lindsay, Calif.

CANADA

G. R. Dewey, Brockville, Ont., is interested in a project to construct an electric power line through Elizabethtown Township. Estimated cost, $25,000.

Press reports state that the Town Council, The Narrows, Man., is considering the installation of a light and power system. The estimated cost is $50,000.

It is reported that B. Gunderson, Park Rapids, Minn., is interested in the installation of an electric-light plant in Menahga, Minn.

The Electric Light & Water Commission of Warren, Minn., is considering plans to double the present output of the municipal electric-light plant. W. R. Haney is Supt., Mgr. and Cont. Agt.

It is reported that the United Water, Gas & Electric Co., Hutchinson, Kan., will enlarge the boiler room of its power plant to double the present capacity. J. F. Springfield is Gen. Mgr.

A bond issue of $28,000 has been voted by the citizens of Fullerton, Neb., the proceeds of which will be used for the installation of a municipal electric-light plant.

The City Council of Drexel, Mo., plans the installation of a municipal electric-light plant. The estimated cost is $10,000.

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